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FOURTH NATIONAL CONFERENCE ON WHEAT UTILIZATION RESEARCH

Held at Boise, Idaho
November 3-5, 1965

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

THE FOURTH NATIONAL WHEAT UTILIZATION RESEARCH CONFERENCE was held November 3 to 5, 1965, in Boise, Idaho. Honorable Robert E. Smylie, Governor of Idaho, and Mr. Harold West, Administrator, Idaho Wheat Commission, welcomed the attendants. Sponsors of the Conference were Great Plains Wheat, Inc., Idaho State Wheat Growers Association, Idaho Wheat Commission, University of Idaho, Western Wheat Associates and the U. S. Department of Agriculture.

The major objective of the annual wheat utilization research conferences continues to be a comprehensive working organization, including all segments of the wheat industry, along with scientists engaged in research. The hope that activates the conferences is that exchange of information will continue to aid and guide all concerned and that improvements will continue to be made. Everyone whose work involves wheat realizes that this crop is a large factor in the world economy and in the health and peace of the world.

The Fifth National Wheat Utilization Research Conference will be held in Fargo, North Dakota, in November 1966.

Speakers and their organizations are responsible for the information they have contributed, and they should be consulted by those who may wish to reproduce their speeches, wholly or in part. Occasional mention of commercial products does not imply recommendation by the U. S. Department of Agriculture.

This report was prepared in the Western Regional Research Laboratory, Albany, California 94710--headquarters of the Western Utilization Research and Development Division of the U. S. Department of Agriculture's Research Service. Copies are available on request. In addition, copies of the reports of the first, second, and third conferences and of an earlier one on "Role of Wheat in the World's Food Supply" are also available.

April 1966

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Fourth National Conference on Wheat Utilization Research

THE NATIONAL COMMISSION ON FOOD MARKETING

H. Wayne Bitting
Project Leader, Bakery and Cereal Products, National Commission
on Food Marketing, Washington, D.C. 20407

Your annual utilization research conference on wheat offers something for everyone involved in the production and manufacturing of wheat foods. It provides the common denominator for farmers, millers, and bakers for mutual improvement and benefit. At your meeting last year, Dr. Ogren stressed the need for better statistics to measure changes in the economics of a loaf of bread. I did not suspect that I might become involved in developing these better statistics. Now I am more than knee deep in this work. I am up to my ears in it--maybe more.

The assignment given the National Commission on Food Marketing provides a terrific challenge. Only with complete cooperation and support from the baking and cereal products industries can we hope to accomplish our tasks in the time allotted. We are receiving this cooperation and support, and it is now a race against time to complete our work by July 1, 1966.

I shall mention a few of our responsibilities. We must document major changes during the last two decades and explain the causes for those changes. Have these causes exhausted themselves or are they still operating? What future changes are likely to come? Will they be desirable? We are required to evaluate the entire system as an integrated unit from wheat grower to retail outlet. In appraising the overall bakery and cereal products industry, we must examine each segment in terms of:

1. Technical efficiency, in the sense of well run, technologically up-to-date and fully utilized plants; effective coordination of operations from each stage of production, manufacturing, and marketing to the next.
2. Economic efficiency, in the sense that the goods and services are responsive to demands of users and finally the ultimate consumers.
3. Progressiveness in developing better products or producing old ones more efficiently as time goes on.
4. Effective competition, of the kind that results in prices and margins consistent with necessary costs and reasonable profits.
5. Equity, in the sense of fair conduct, absence of exploitation, and comparable returns on labor and investment.

As you probably know, the National Commission on Food Marketing is bipartisan. It consists of 5 senators, 5 representatives, and 5 private citizens appointed by the President. They are:

Hon. Warren G. Magnuson
Hon. Gale W. McGee
Hon. Philip A. Hart
Hon. Thruston B. Morton
Hon. Roman L. Hruska

Hon. Leonor K. Sullivan
Hon. Graham Purcell
Hon. Benjamin S. Rosenthal
Hon. Glenn C. Cunningham
Hon. Catherine May

Hon. Phil S. Gibson, Chairman
Hon. William M. Batten
Hon. Elmer R. Kiehl
Hon. Fred J. Marshall
Hon. Albert K. Mitchell

A staff has been set up to serve the Commission. Dr. Brandow is our director. The staff is comprised of a legal division, five separate study projects on specific food industry subjects, and supporting administrative and information personnel. One project deals with food retailing. The other four deal with classes of commodities--dairy products, meats and poultry, fruits and vegetables, and bakery and cereal products. On June 30, 1965, our staff numbered 41 regular full-time employees, 27 of them professional. This represents one regular full-time employee for each $2 billion of total food sales if we include restaurant and institutional sales.

We have held no public or closed hearings in bakery and cereal products. Instead, we have gone to the millers, bakers, cookie, cracker, and breakfast cereal manufacturers and asked for their cooperation and support in developing questionnaires which would accurately supply information needed to document industry changes and make an industry appraisal. At present we have received most of the questionnaires mailed to flour millers, cereal manufacturers, and cookie manufacturers. The bakery questionnaire will be mailed soon.

Effort has been spent in developing questionnaires which are practical and will yield accurate information with minimal effort. Extreme care has been exercised to insure that reporting firms cannot be identified and that the confidential nature of the data will be maintained. As Dr. Ogren will probably mention later, the Food Commission has an arrangement with the Department of Agriculture for tabulating and analyzing data. Without help from Dr. Ogren's staff I would be unable to complete my assignment. It is our sincere desire that the technical report on bakery and cereal products will provide a benchmark on which the industry can build and make future improvements.

AN ECONOMIC INTERPRETATION OF WHEAT, FLOUR, AND BREAD PRICES

Kenneth E. Ogren
Economic Research Service, USDA, Washington, D.C.

The obstacles to data collection have grown as rapidly as have the needs for statistics. In the early 1900's packaging, advertising, and other factors were not involved in the retail price of bread. Changes that have complicated the collection of data on white bread include the first commercial wrapping in 1908 or 1909, which elevated bread from "a pile of cord wood" to a "branded, protected, processed food" (Sperry and Cohen, Bread Brans, E. J. Sperry

Industrial Publications, Chicago, 1949); the first sliced bread in the late 1920's; the first jumbo loaf after the depression of the 1930's; and the enrichment advertising prior to World War II. Since World War II innovations include round loaves, resealable wraps, an attempt by some to duplicate the old home-baked style. Just 60 years earlier, the industry had urged the housewife to give up home-made bread in favor of "baker's" bread, which, incidentally, became one of our earliest convenience foods.

Each of these innovations helped bakers to differentiate their products. In a supermarket today, it is not uncommon to find over 20 varieties and types of bread. White bread is no longer _a_ food item, but rather a _full line_. What are we talking about when we speak of white bread?

Couple this question to the fact that the assembly of wheat may follow several channels of trade. Transportation of products may be by rail, truck, or water. Flour millers mill more than just white bread-type flour. Bakers make many products in addition to white bread. Distribution is made by several methods. And retail prices vary for numerous reasons. We have a very complicated picture indeed. By keeping in mind the obstacles to determining _the_ average U.S. price of white bread, you will understand some of the problems we face and the reasons we are striving to improve our price spread studies.

In the recent past, our published price spreads for white bread have been based on the best secondary data available for estimating the various components of the price of a loaf of bread. For the farm value, we use the average monthly price received by farmers for wheat as reported in the USDA Agricultural Prices series. The Statistical Reporting Service assembles these prices from reports by field men throughout wheat-producing regions. Cost of wheat to millers is based on the average price of hard red winter and hard red spring wheats at six markets adjusted by the Census of Manufactures' reported cost of wheat to mills. The mill sales value of flour also is based on average flour prices at major markets and adjusted by the Census of Manufactures' reported mill sales value. Cost of flour to the baker is based on the adjusted mill sales value of flour multiplied by the amount of flour per pound loaf (0.641) as reported by the baking industry and the American Institute of Baking. The cost of other ingredients to the baker is based on various industry trade reports.

The wholesale price of bread is based on the average wholesale price for four cities (New York, New Orleans, Chicago, and San Francisco) as reported by the Bureau of Labor Statistics, adjusted according to a National Bread Price Survey and the BLS average retail price. The retail price of bread is based entirely on the weighted average price as reported by the Bureau of Labor Statistics.

BLS field agents price the largest-volume selling loaf in each of their sample stores; BLS specifications call for pan-style bread, wrapped, prepared from white flour. This is white bread. Yet the volume-selling white bread in one part of town may be much different from that selling in another part; and the volume-selling white bread may account for a small percentage of total white bread sales in some stores. Hence, our farm-retail price spread series for white bread, based on these data sources, are only the best approximations possible. We have continually adjusted our data to take into account technological and other changes. Although we realize our series is only approximate, we are nevertheless confident that our white bread price spreads have accurately reflected changes over time.

Who gets what and why? With this background, let's look at the price of a loaf of bread and the change in the component price spreads. Unusually intense interest has been paid to white bread prices during the past year because of the wheat certificate issue and the proposed farm legislation. In response, the Department published a leaflet designed to answer the question, "Who gets what and why?" (Bread and Wheat Price Trends, Economic Research Service, USDA, April 1965). Data show that the average retail price of bread did not increase in 1964 for the first time since the 1947-49 base period. The average price of a 1-pound loaf was 20.7 cents in 1964, equal to the 1963 price.

The data in this leaflet were based on a new series of retail bread prices. Effective January, 1964, BLS changed its sample and processing procedures to get a more representative sample. As a result, white bread prices were lowered. To maintain a comparable series, we adjusted our figures accordingly. The 1963 average retail price of a 1-pound loaf of white bread was adjusted downward from 21.6 to 20.7 cents.

Figure 1 shows us that in the first 9 months of 1965 the U.S. consumer paid an average of 20.9 cents for a 1-pound loaf. Generally, the price of bread was divided about the same in 1965 as in previous years, with the baker-wholesaler function accounting for most of the farm-retail spread. The farmer's share and the retailer's share increased over the 1964 level by 0.1 and 0.2 cent, respectively. The miller's share decreased from 0.9 cent in 1964 to 0.8 cent in the first 9 months of 1965. The baker-wholesaler's share (11.4 cents) and the amount shown for transportation, handling, and other processing (1.5 cents) remained the same in the first 9 months of 1965 as in 1964.

My next chart (Figure 2) shows the change in the retail price of a pound loaf since 1947-49 and changes in the distribution of the retail price among the retailer, the baker, the miller, and the farmer. The most significant statistic is the rise in the price from 12.7 cents in 1947-49 to 20.9 cents in the first 9 months of 1965, a 65-percent increase. Since about 1961, the retail price has tended to level off. However, the up-turn in 1965 indicates that the period of level prices may be broken.

The main reasons for the increase since 1947-49 are the higher costs of baking and distributing a loaf of bread. Almost all costs are up--wages, wrapping materials, vehicle expense, and selling costs. Hourly earnings of production workers in bakeries rose from $1.15 in 1947-49 to $2.40 in 1964. In recent years the baking industry has found ways to offset some of these cost increases through mechanization. These savings have been especially evident when the price rise has averaged less per year in recent years than in the early part of the post-war period.

The baker-wholesaler price has risen nearly as fast as the retail price since 1947-49, 57 percent as compared to 65-percent increase in the retail price. The farm value of wheat and mill sales value of flour have remained relatively low. The farm value (2.7 cents) was exactly the same in the first 9

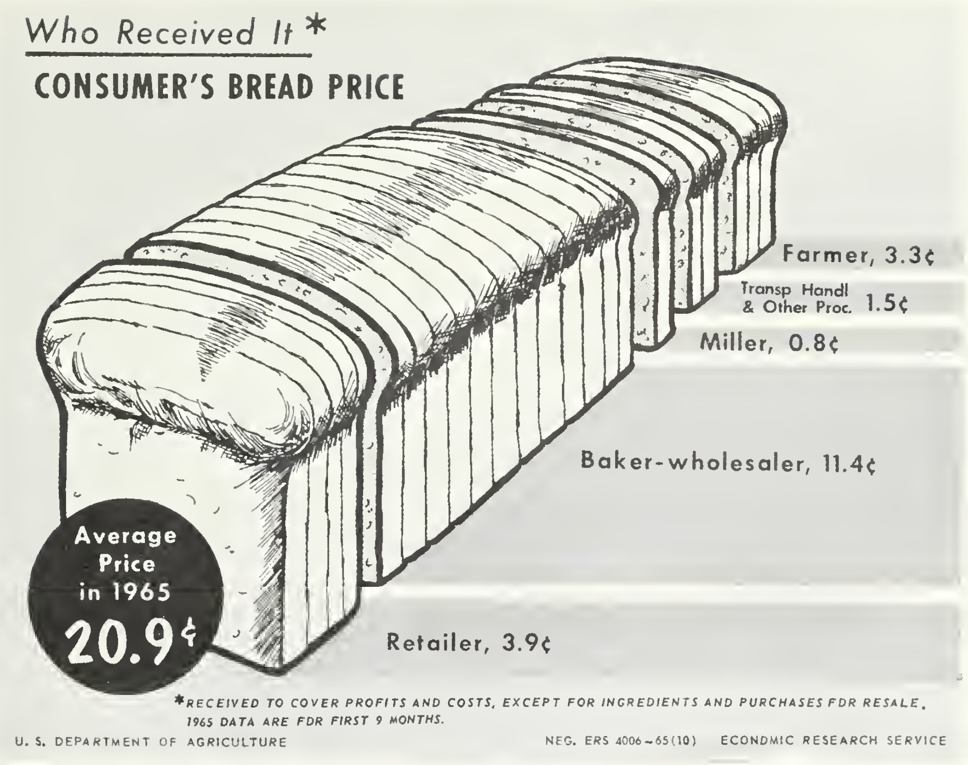


Figure 1

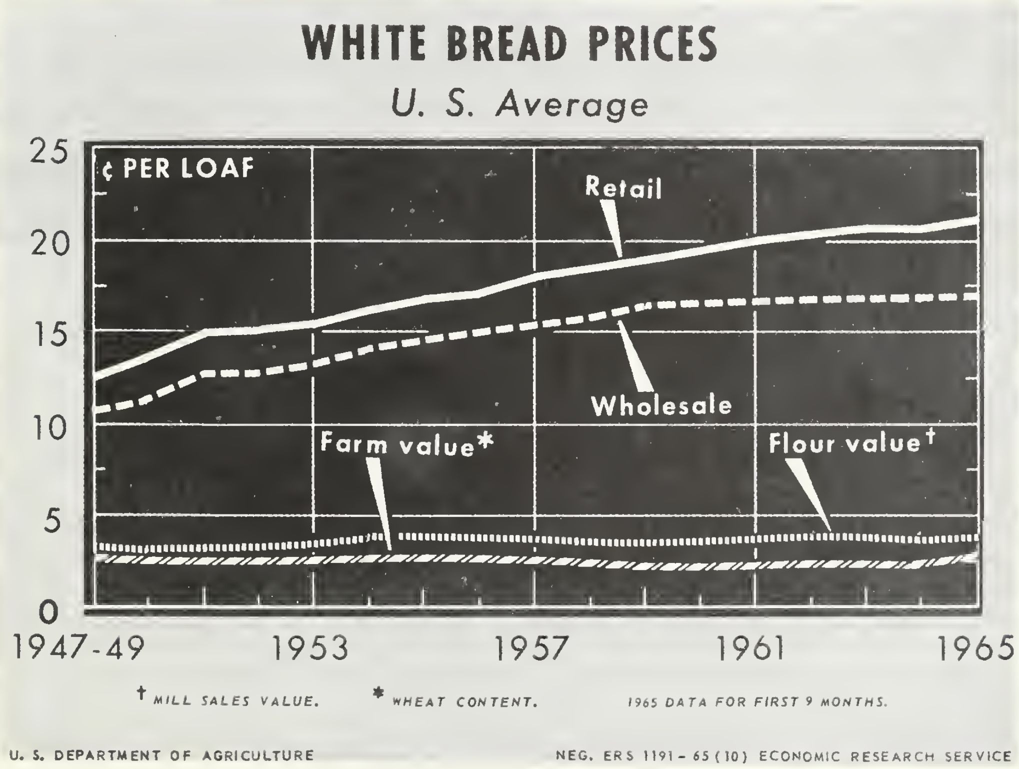


Figure 2

months of 1965 as in 1947-49. The value of flour increased slightly from 3.4 cents in 1947-49 to 3.9 cents in the first 9 months of 1965, or about 15 percent.

Figure 3 shows a vivid picture of how the farm-retail price spread has widened since 1947-49 in relation to the farm value of ingredients. The farmer's share was 26 percent in 1947-49. In the first 9 months of 1965 it was 16 percent. Figure 4 shows the change in the retail bread price and the farm wheat price in percentage terms (1947-49 = 100). Again this chart shows a similar picture. The retail prices are steadily increasing, although at a slower rate in recent years. The price received by farmers for wheat has shown a relative increase in the last 3 years.

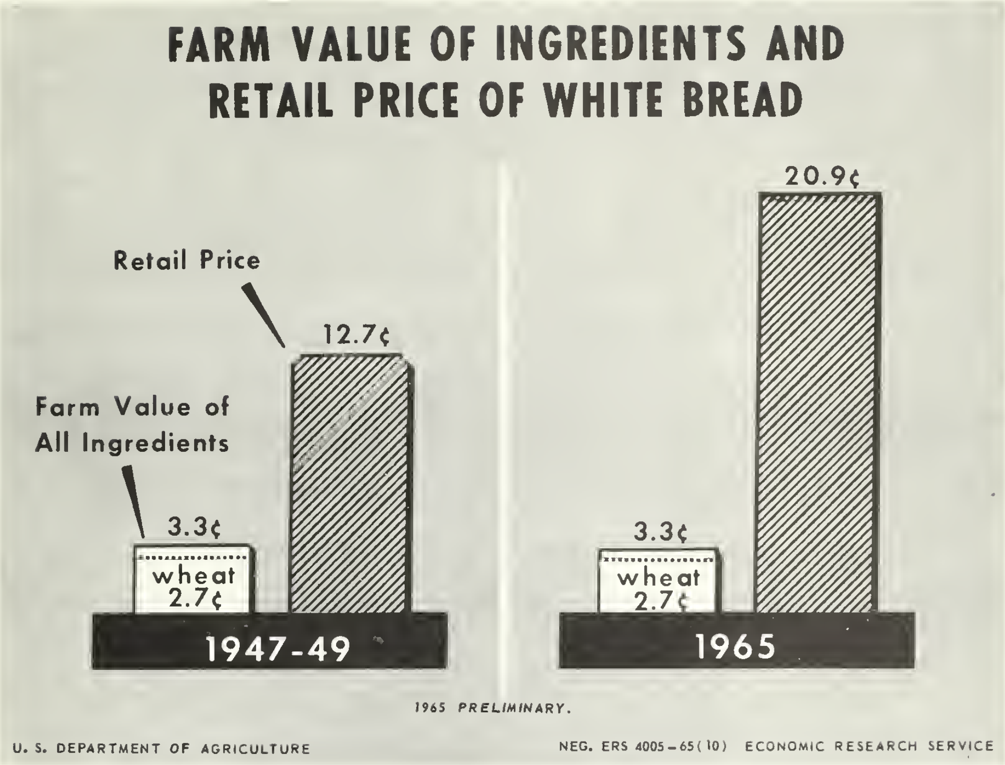
Who gets what and why? An economic interpretation must not stop with a chart depicting shares taken by various marketing agencies. The farmer's share is low. The miller's share is declining. Apparently, neither of these two sectors is getting rich off the production of wheat and flour going into white bread. But the percentage share is not a satisfactory measure of profits.

The baker-wholesaler gets the largest share of the consumer's white bread dollar. Yet Figure 5 shows that profits of the five major baking companies are actually decreasing while wholesale price is increasing. Since 1947-49, profits as percent of sales have decreased generally, with a rather sharp decline in the early 1960's. Although it is too early to know the profit level for 1965, first and second quarter figures indicate that profits of the five major baking companies before taxes are the same as in corresponding quarters in 1964. Profits after taxes appear to be slightly higher, standing at 1.1 percent as compared with 0.9 in corresponding quarters in 1964.

An economic interpretation of retail price spread is most difficult when narrowed to a 1-pound loaf of bread. At this time we do not have sufficient data to explain the components of the retail margin. We do know that it has widened at about the same rate as the baker-wholesaler margin and expect that some of the same causal factors are at work. A look into food retailing is one of the major tasks of the Food Commission. Hopefully, some light will be shed on the economics of retailing.

After a careful examination of who gets what, it seems that the farmer, the miller, the baker, and probably the retailer do not get what they appear to get. But why? The increase in the price of white bread is not caused by actions of the miller or baker, but rather by an economic phenomenon known as "cost push." The concept "cost push" is one which may exist only when there is excess capacity and absence of "demand pull." This is the situation in which much of the industry involved in production of white bread finds itself today. The costs of inputs have been pushed up, necessitating higher prices to cover costs. Wage rates, for example, increased 109 percent from 1947-49 to 1964. Only technological innovations prevented a much greater increase in prices.

What are we doing to improve our statistics? Seemingly statistics are becoming more and more a vital part of our life. In the changing nature of our society statistics become the basis for more and more opinions and decisions for the public at large as well as farmers, businessmen, and lawyers. These changes

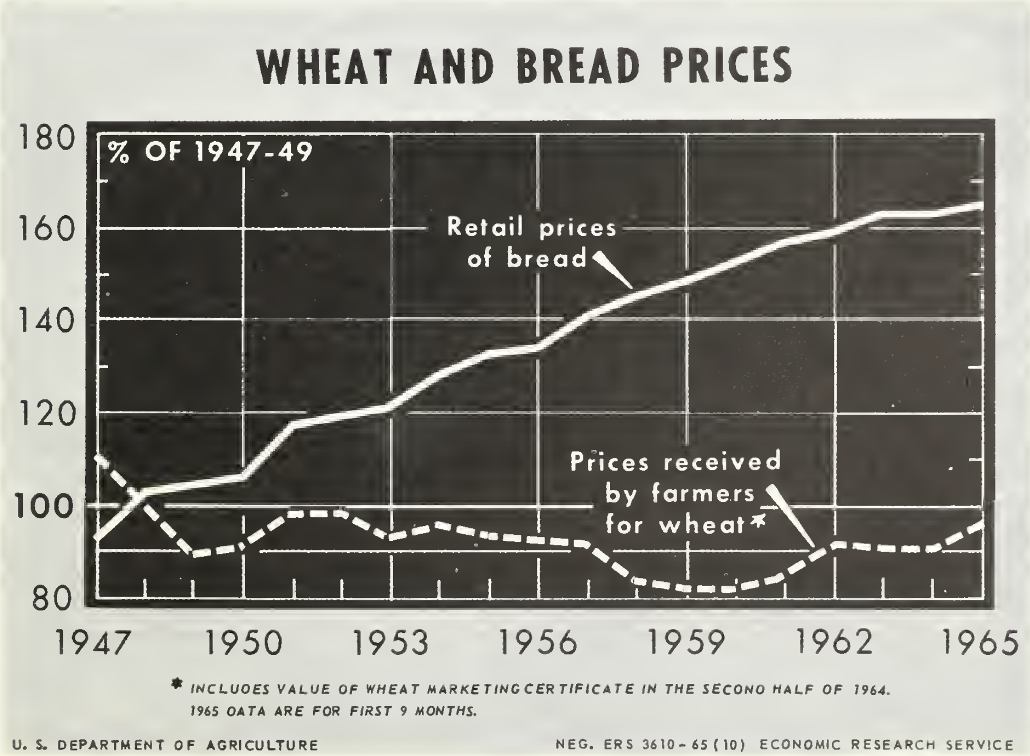

FARM VALUE OF INGREDIENTS AND RETAIL PRICE OF WHITE BREAD

1965 PRELIMINARY.

U. S. DEPARTMENT OF AGRICULTURE

NEG. ERS 4005-65(10) ECONOMIC RESEARCH SERVICE

Figure 3


WHEAT AND BREAD PRICES

* INCLUDES VALUE OF WHEAT MARKETING CERTIFICATE IN THE SECOND HALF OF 1964.
1965 DATA ARE FOR FIRST 9 MONTHS.

U. S. DEPARTMENT OF AGRICULTURE

NEG. ERS 3610-65(10) ECONOMIC RESEARCH SERVICE

Figure 4

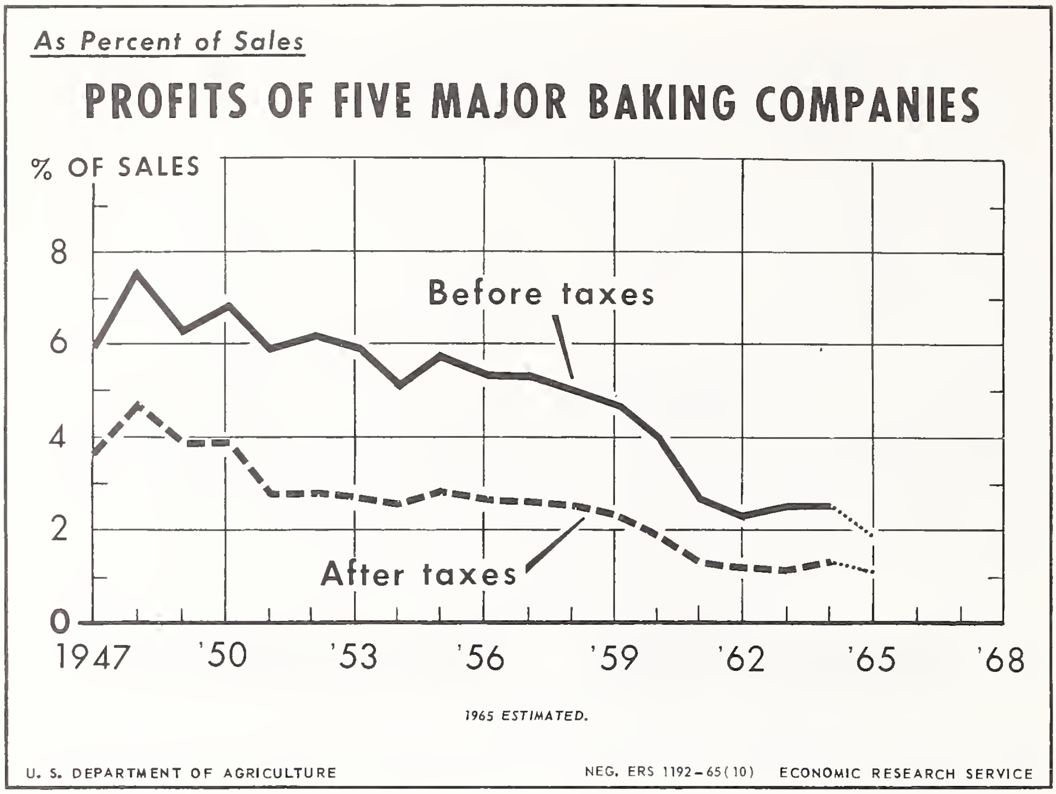


Figure 5

intensify the need for greater accuracy--at a time when rapid change intensifies challenges and problems for those who develop statistics.

In the past year, Department representatives have met with milling and baking trade associations and industry members to study data sources and computational methods. These meetings were very fruitful. For example, the Millers' National Federation provided the Department with its first sound evidence of the trend toward bulk shipments. When account is taken of the lower price of flour used in a loaf, it lowers the estimated price received by the millers by about 0.1 cent and hence lowers the miller's flour spread estimated for February 1965 from 0.8 cent to 0.7 cent. This is not large, but percentagewise it is significant.

The meeting of milling and baking representatives with the Secretary of Agriculture last November provided an impetus for improving statistics on flour prices paid by bakers. Thus far, we have received a generous amount of data on flour prices from several baking companies. These data are being used to evaluate the series of flour prices collected and published by the Bureau of Labor Statistics which currently provide the base for our estimates of flour cost and prices.

The National Commission on Food Marketing also has furthered industry-government cooperation. Prior to creation of the Commission, government-industry cooperation was just in the bud. Now there are signs that this cooperation may reach full bloom. Recently members of the Commission, U.S.

Department of Agriculture, and industry have met several times and have developed a fruitful interchange of information. We need more than periodic Census of Manufactures data to derive accurate white-bread farm-retail price spreads. We need more than the data collected by the Bureau of Labor Statistics from food stores that voluntarily report their selling prices. With the cooperation of industry and added interest and insights provided by the Commission, we expect to improve our basis for computing price spreads.

The Food Commission with the Department's cooperation is making detailed cost studies of the milling and baking industries. In both cases, these studies involve the collection of detailed cost information--cost of materials, manufacturing costs, administrative costs, and selling and distribution costs. Since our cost spread studies are necessarily based on U.S. averages, these studies will help us determine if our present methods are in reality properly based. The milling study, for instance, will provide us with the flow of whole wheat to mills by point of purchase by mill and by type of transportation. We will learn more about the transportation bill and who pays it. We will be able to determine distribution channels by sales outlets and again by type of transportation used. We hope to obtain similar data from wholesale and chain store bakers. Also, we are asking for separate sales and distribution information on private-label and manufacturers' brands of white bread. This is an area that we have not explored in the past.

There is growing evidence that price spreads vary greatly, depending on whether we are talking about private-label bread or manufacturer brands. In a recent study it was found that 71 percent of the bread sales of six selected food chains involved private-label bread. According to this study, the net margin before taxes per 1-pound loaf of private label bread averaged 0.5 cent during 1959-63. This compared with an average net margin before taxes of 2-3/4 cents on a 1-pound loaf of manufacturers' brand bread (Marketing Costs and Margins: Current Use in Agribusiness Market Structure Analysis, prepared by Ray A. Goldberg, Harvard Business School, for American Farm Economic Association meeting, Oklahoma State University, Aug. 25, 1965).

Along this line, the Department hopes to strengthen its pricing data at the retail levels. BLS data are our only source. BLS retail prices are collected monthly by field agents from a sample of chain and independent retail food stores who report their selling prices. Prices for the designated sample are collected monthly on Tuesday, Wednesday, or Thursday of a specified week preceding the 15th day of the month. Prices collected are those for the largest-volume selling loaf on the day of the agent's visit and include any sale or weekend special prices offered on that day. The primary purpose of BLS prices is to measure change, not to provide data for price-spread studies.

Because white bread is marketed in many forms, types, and varieties, actual pricing practices may not be reflected by the volume-selling loaves. The Department has reason to believe the volume of white bread moving on weekend sales as opposed to the earlier part of the week may differ. We have evidence of price differences by income areas of a given city. BLS weights observed prices on the volume-selling white bread on the basis of food sales of chain grocery stores, other large stores, and small food stores. This does not take into account the inelastic demand for white bread. In other words, white bread sales relative to total food sales would be expected to be less in higher-income than in lower-income areas. However, total quantity of bread products sold may be more responsive to income levels than white bread alone. There is some evidence that higher-income families buy increasing amounts of specialty breads and other pastry goods.

In addition to the flour milling, wholesale, and chain-bakery studies, we are working in another area. In cooperation with Agricultural Stabilization and Conservation Service, the Economic Research Service is conducting a detailed analysis of the grain assembly operations. In cooperation with Oklahoma State University and the Texas Transportation Institute, we are collecting transportation cost data on both wheat and flour. These studies will provide added information on another important area which makes up about 7 percent of the farm-retail spread. As each of these areas is studied, we are attempting to separate our transportation costs by method of distribution.

Where to from here? We can identify with reasonable accuracy the relative shares of a loaf of bread: e.g., the baker, the largest share; the miller, less than 1 cent; the farmer, about 3 cents for all ingredients; etc. But being close counts only in a game of horseshoes. Absolute accuracy is related to current questions asked by Congress and the Food Commission. It is more difficult to measure the exact figure to 0.1 cent month after month, year after year. The exact figures can be derived only with close industry-government cooperation.

White bread farm-retail-spread information is proving to be a much observed performance measure. These statistics provide the public--farmers, consumer, and Congress--with up-to-date information on trends in prices, costs, and profits. Interest in the farm-retail spread of all food products was apparent in the creation of the National Commission on Food Marketing. Interest in a specific farm-retail spread was evidenced in the recent proposed farm bill. If legislation is to be influenced by economic interpretations, then it behooves private industry to see that such interpretations are based on complete and accurate information.

The Department will continue its efforts to improve its data by working more closely with industry. We urgently solicit full cooperation to assure us that we are making accurate interpretations. We welcome the opportunity to improve our statistics through use of data supplied by industry. We hope that our promising start is a harbinger of continued cooperation.

Harlan Cleveland, Assistant Secretary of State for International Organization Affairs, made a significant comment in a talk on "The Blurred Line Between Public and Private": "Compared to a generation ago, our private enterprise system is just as enterprising as ever, but not nearly so private." Cleveland noted that business firms and their managers are acting more and more in ways that tend to blur the division between public and private. This blurred line is especially true in the case of bread, a basic food item, which has extreme public as well as private interest. ("Ethics and Bigness: Scientific, Academic, Religious, Political, and Military." Edited by Harlan Cleveland and Harold D. Lasswell. Papers for 16th meeting of Conference on Science, Philosophy, and Religion, Harper & Bros., 1962.)

A REPORT ON THE WHEAT AND WHEAT FOODS FOUNDATION

Howard L. Morton
Chairman, Research Committee, National Association
of Wheat Growers, Longmont, Colorado

There is perhaps no better way to open this Fourth Annual Wheat Utilization Research Conference than to review progress on the organization of the Wheat and Wheat Foods Foundation. The Foundation was much in the news last spring and early summer. In meetings sponsored by the Secretary of Agriculture, wheat producers, flour millers, bakers, macaroni manufacturers, bulgur processors, cookie and cracker bakers, and even representatives of bakery union labor joined in common recognition of a community of interest in planning the Foundation.

Implicit in a community of interest is the acceptance of common problems--problems too great for any one single-interest group to solve. Simply stated, our problem is a declining domestic market, coupled with rapidly expanding world need for food. We are at a crossroads: Either we increase wheat consumption, both domestic and foreign, by proving its merit and promoting its products, or lose out to other commodities and products which are aggressively seeking markets.

As a wheat farmer, I have always shared with other producers a preoccupation with foreign outlets for wheat and flour. Perhaps we even neglected the domestic market in our preoccupation. We were trying to skim the cream, so to speak. But, at the same time, there has always been some recognition that one must have milk before one sells cream. Not only that--there is always more milk than cream. The urgent, almost desperate need for a domestic marketing program --as well as foreign marketing--is fundamental to the organization of a Wheat and Wheat Foods Foundation. We need a marketing program on the same scale as the problem itself. And that means BIG.

If you are concerned with dairy interests, you find a prototype in the American Dairy Association and the National Dairy Council. If your concern is meat, you can turn to the National Live Stock and Meat Board. Or, if you produce fresh fruits and vegetables, there is an equivalent marketing program of size and vigor to match the need. But if you are concerned with wheat--as a producer, processor or end-product manufacturer--where do you turn?

You find a Wheat Flour Institute supported by millers. There is a Consumer Service Department in the American Institute of Baking. There are domestic marketing programs in Kansas and North Dakota. But these organizations almost represent division rather than community of interest. Together, their financing hardly totals more than a half-million dollars, compared to an estimated 15 million each year in the dairy industry. For a first time, in the Wheat and Wheat Foods Foundation, we have the potential organization of magnitude sufficient to the task. We have a chance to stand together and to speak with a single voice, loud and clear enough to be heard, and to be an effective instrument in our marketing effort.

Program Outline

WHEAT AND WHEAT FOODS FOUNDATION

Producers o Processors o End-Product Manufacturers

Board of Directors

Administration

I. THE BASIC PROGRAM

A. RESEARCH
- (1) Human Nutrition
- (2) New Products
- (3) Nonfood Industrial
- (4) Market Research

B. EXTENSION AND EDUCATION SERVICES
- (1) Field Service
- (2) Nutrition Education
- (3) Teaching Aids
- (4) Demonstrations Workshops
- (5) Professional Speakers
- (6) Exhibits Displays

C. Mutual Facility

--

- Editorial Photography
- Writing and Production Service All Media
- Test Kitchen Recipes

D. PROFESSIONAL ADVERTISING
- (1) Medical Market
- (2) Home Economics
- (3) School Market

E. PUBLIC AFFAIRS ACTIVITY
- (1) Special Events Awards
- (2) Member Services
- (3) Public Information Services

II. THE END-PRODUCT PROGRAM--ADVERTISING o MERCHANDISING o PROMOTION

- (A) Consumer Adv.
- (B) Trade Adv.
- (C) Special Promotion
- (D) Market Research
- (E) Product-Use Editorial Service
- (F) Special Markets

III. THE FOREIGN MARKETING PROGRAM

There have been, and will continue to be, many problems. Those of you who have been associated in the organization of a Wheat and Wheat Foods Foundation may share with me the deep conviction that it is amazing that we have stayed together so long. And with every month, week, day, or hour that we stay together in the Foundation organization--the better are our chances for ultimate success.

It has generally been conceded that we must agree upon a program before we turn to the knotty problem of financing. In recent weeks a program has been developed--a program that has thus far received the enthusiastic support of all to whom it has been exposed. Today, I would like to summarize that program. The immediate and long-range welfare of every person here will be affected. There is something in it for each of you, no matter where your primary interest may be. Each of us must personally realize that there is something in the program for him--if it is to succeed. Incidentally, the question of financing will be taken up later this month at a meeting of a subcommittee of producers, processors, and end-product manufacturers in Washington.

Let me say that it has been generally agreed that the program of the Wheat and Wheat Foods Foundation shall be conducted exclusively in nonpolitical areas. It will represent our mutually accepted plan of attack on common problems. It has also been agreed that no part of the program shall challenge or supersede any of the existing separate programs among wheat growers or millers, or those for breakfast cereals, bulgur, baking or macaroni manufacturing.

We have agreed on Articles of Incorporation. We have a Board of Directors representing producers, processing, and manufacturing groups. We start with a basic program chiefly concerned with research and education, with professional advertising, and with public affairs activity. We have chosen to call what people ordinarily think of as public relations by the more acceptable name of public affairs--to avoid the sometimes bad implications of public relations.

Next we have a program of end-product promotion in advertising, merchandising, and sales. Finally, there is a foreign marketing program--which will use the facilities and resources of the total organization in developing and promoting markets for our products overseas.

The basic program represents considerations fundamental to education and promotion in behalf of all, any class, or individual kinds of wheat products, regardless of their form, origin, or route to the consumer table. The basic program is the bedrock of the Foundation--with research, extension, and education services, professional advertising, and public affairs activity. If you combine the activities of the separate programs of the Bakers of America, the Consumer Service of the American Institute of Baking, the Wheat Flour Institute, the National Macaroni Institute and similar organizations working in behalf of wheat--they add to something very much like the basic program. Let's take them one by one.

In research, we start with human nutrition--an area where our urgent need has been spelled out in detail in the publication "A Program of Needed Research," prepared and published by the Pro Tem Committee--Human Nutrition Research. We all know that questions concerning the nutritive value of wheat flour products have inhibited or limited consumption of our products both at home and abroad. At every recent conference, whether on nutrition or world food needs, we read or hear the cry of protein need. And by protein, those scientists mean milk, meat, fish, or eggs.

But the work of the Pro Tem Committee tells us that wheat foods are excellent sources of protein as well as other nutrients--that wheat products can be used to minimize blood serum cholesterol and other factors involved in heart disease (today's number one man killer in America). And there are still other attributes of wheat awaiting investigation or confirmation in research. I urge you to read this pamphlet on the need for further research.

New product research immediately suggests the development of forms of wheat such as bulgur. There will be others. In nonfood and industrial uses of wheat, we can anticipate expanding our market in other directions--for instance, in animal feeds, or gluten as a high-protein substance, or in new uses for starch fractions.

And finally, we have market research--both as part of the basic program and in end-product promotion. Market research will help us know why people accept or reject products of wheat, how best to present our products in the marketplace to make them more appealing--in short, how to tell our story to best advantage.

With research to provide information, we move into the extension and education services. Establishment of a field service is contemplated--a force to match the several hundred specialists employed by the dairy industry, for example, to tell our commodity story in educational circles.

Nutrition education is set up separately--simply because we know that people who are more aware of the good nutrition in wheat products eat more of them. Then teaching aids--booklets, pamphlets, movies, filmstrips, and similar materials--to help teachers teach, and students learn, about the virtues of wheat flour foods. Demonstrations, the enlistment of professional speakers, and the use of exhibits and displays are all part of the extension of the basic program.

Next we come to publicity and editorial services, together with organization of creative talent required to produce teaching aids or booklets, filmstrips, pamphlets, and the like. We have called this a mutual facility simply because it would serve almost all departments of the Wheat and Wheat Foods Foundation. A testing kitchen for the development of wheat food recipes is essential, along with writers and those skilled in food photography. We should aim to serve newspapers, magazines, radio stations, and television broadcasters with as much material and information as they can use and digest.

Moving to the area of professional advertising, here you can consider the printed word in magazines designed for special markets as another extension of the basic program. In professionally accepted copy, we would tell physicians, dentists, and nutritionists the story of wheat products, their nutritional values, adaptability, flexibility, and merit. We want professional home economists to know and recognize the value of wheat flour foods both in their teaching and writing. We want to tell teachers everywhere about wheat and wheat products so that they can incorporate parts of the story in their curriculum for students at various education levels.

In public affairs (or public relations) we have proposed both an intensive and comprehensive program to inform the general public and special groups about wheat and its products. Those of us who are wheat producers know something of the public reaction when one identifies himself as a "wheat farmer." The public has been led to believe that you are almost on a dole of government subsidies. Let me illustrate: Many of us have had similar experiences, but at least one of my fellow wheat growers tells it this way: He and his wife were introduced at a party, identified by name. Someone among those he had just met asked what his business was. He said, "I am a wheat grower." The response was "Oh, one of those fellows we taxpayers support."

We wheat growers may think that this problem is exclusively ours. But--not so. In areas totally unrelated to anything connected with the proposed Wheat Foods Foundation, millers and bakers experience the same sort of treatment. We may differ from millers and bakers about the wheat program, but certainly we have a common problem in the lack of public knowledge and understanding of our industry.

What came out of Washington this year as wheat legislation may be viewed by some as a magnificent compromise. Neither the baker, nor the miller, nor the wheat grower got everything he wanted. On the other hand, each of the three separate groups--and again, I stress that this has nothing to do with the proposed Wheat and Wheat Foods Foundation--can claim partial victory. While wheat growers did not gain their certificate plan in full, the Congress saw fit to retain the principle of the certificate. While millers and bakers were not able to eliminate the Certificate, they gained partial victory in Congressional refusal to extend the plan. While the wheat grower lost his fight for full parity under a Certificate Plan, he was assured of parity price for his product on the domestic market.

We could take the story and review it in many different ways. It was a compromise--a compromise from which each of us gained something. But the after-effect is something different--especially for bakers. The Conference Committee voted out the escalation clause--in which the Secretary of Agriculture would be authorized to increase the price of wheat paid to farmers according to the advance, if any, in the price of bread. But some aspects of this idea were retained in the legislation--so that the Secretary of Agriculture periodically must review bread prices and consider the prices paid farmers in relation to what bakers charge in the marketplace. The bakers thus feel they too have some explanation to make to the public--about their costs, their profit margin, and their product.

Within the dimension of "public affairs activity," the proposed Foundation would try to solve some problems for each of the different interest groups. The special events suggested in the Program of the Foundation would include economic studies and their publication, so that the public might be made more aware of some of the difficulties confronting wheat growers, processors, and end-product manufacturers.

Another important aspect, in the Foundation as with any similar organization, is the problem of keeping members informed. All of us who are active in organizations know that sometimes the job of advising members what has been done looms as greater than merely doing what should be done. Or, at least it seems to be the more important job of the moment. And here, too, we would have another task. The maintenance of a Bureau for Public Information, and the dissemination of information, both about the Foundation's program and special activities, would reside in this area of operation.

Change the name "Wheat and Wheat Foods" to "Corn" or "Milk and Dairy Foods" or any name for any other commodity or group of food products you wish, and the basic elements of the program will remain the same. The knowledge and experience of hundreds of competent, skillful, talented people have gone into building this pattern for a basic program. We can adapt and modify to our own advantage any one or many of the elements from similar programs operated in behalf of a dozen or more basic commodity groups. The basic program is the crux. It is the "foundation" of the Foundation, so to speak--including the elements which almost any person knowledgeable in such areas of human endeavor might recommend.

Without going into questions of financing the Foundation, let us say that the basic program comes first--and that end-product advertising, merchandising, and promotion follow. In other words, money left over, or residual after the financing of the basic program, would be devoted to consumer advertising, trade advertising, special promotions, market research, product-use editorial services, and special market promotion. This is not to say that the money used for end-product promotion would be more or less than that used for the basic program. Hopefully, it would be the larger amount, much larger, and with something sizable to leave for foreign market development as well.

There is however a conviction on the part of those who joined in the planning of the Foundation program that the "basics" come first. Depending on total resources available to the Foundation, according to whatever plan of financing is agreed upon and followed, the basic program would provide the ammunition or knowledge plus the mechanics to make effort toward end-product promotion and foreign marketing more fruitful.

At this time it is difficult to discuss the various aspects of end-product promotion. It would be presumptive on my part, for example, to discuss consumer advertising without the counsel and advice of an advertising agency with talent, experience, and creative skill--to tell us how we can best inform the public concerning our product benefits. We are certain however that an investment in consumer advertising would pay dividends. Studies show that products which are advertised sell in greater volume than those not advertised. Moreover, as pointed out in the introduction to this program prepared for the Foundation's Board of Directors, advertising generates repeat buyers or loyalty to product among the mass of consumers--those people upon whom we must depend for the continuing sale of our products. As soon as possible, the program, illustrated by graphs and other material, will be published. I urge each of you to study it carefully.

Then we need trade advertising to tell people involved in the distribution of our product--the wholesalers, cooperative distributors, brokers, salesmen, retailers, and others involved in the chain of distribution--something about what we are trying to do--especially in relation to consumer advertising and special promotions. Special promotions include such merchandising events as the August "National Sandwich Month" campaign and the July "Outdoor Eating" promotion. We need market research in the end-product program just as we need it in the basic program--to tell us why consumers buy or reject the products of wheat, and how best we can marshall our statement of product benefits to appeal to the greatest number of consumers.

Editorial service or "publicity" is another essential of end-product promotion. Here, according to the outline of the program, editorial services would again be derived from the mutual facility described above--in writing and production for all media, a testing kitchen, photography and the like. Finally, we come to special markets--special programs devised for ethnic or cultural divisions of our population--such as labor, Negroes, agriculture, teenagers, the geriatric groups, and similarly defined segments of our population.

And at last we come to that area that has been close to the heart of wheat producers for as long as they have been active in the marketing area--foreign market development. I have mentioned the basic program of research, extension and education service, the writing and production of materials, recipes, photographs and editorial copy, professional advertising, public affairs activity, and end-product promotion in all its phases. All will contribute resources in creative talent, know-how, knowledge, experience, background, and other facets of fundamental work. All will contribute to foreign marketing.

We recognize that while we have wheat surpluses in this country on restricted acreage, coupled with the expanding food needs in other parts of the world--the problem is largely economic. Then, how do we make it economically or commercially feasible to move the surpluses into channels of world trade?

At the same time, there are many garden-variety problems to solve in foreign market development. There are trade barriers with individual nations and negotiations with groups of nations. We can offer technical assistance in some markets. In others, we must do our best to make our American products more competitive. We must know more about the individual markets. Who decides to buy and who uses wheat and flour? What is needed to make more effective our sales techniques? We need skilled representatives abroad to help break down barriers and smooth the way for the sale of our products. And finally, we must help teach people overseas to appreciate wheat foods and prepare them in such ways that they are popular according to ethnic or cultural preferences.

I'm sure you agree that we wheat producers who have so long been concerned in the main with foreign markets still must pay more than passing attention to sale of the "cream." But with a fully and completely organized program, we also have attention paid to the market for milk--the milk which must be separated before we have any cream to sell. For a first time on full scale in this program of the proposed Foundation we would be concerned with our total market: the cash market for our products at home and the cash, barter and credit market for our products overseas.

DEVELOPMENT OF THE WHEAT MARKET IN JAPAN

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It is a pleasure to appear on the program of this Fourth National Wheat Utilization Research Conference. The subject assigned to me, fortunately, is a familiar one. I have been closely involved in the wheat market development program in Japan since we started working there in 1954.

Background information on Japan. Before discussing market development, let's talk about the country and people in Japan. Japan consists of four main islands, and over 500 small ones. The islands form a narrow barrier about 1,300 miles long, roughly the shape of California, but smaller in land area. The terrain is mountainous. Only 15 percent of the land is considered tillable. There are extreme variations in climate--from the northern points having snow as deep at times as 6 to 8 feet to the semitropical southern regions.

About 98 million people now populate this highly industrialized nation. Before the war, the Japanese managed to eat relatively well by importing rice from the two colonies of Korea and Formosa. Conversion to wheat foods on a significant scale started with Japan's defeat in the war. With a nationwide shortage of rice, the people had to eat whatever was available--which, fortunately for us, was wheat. The Japanese are traditionally a rice-eating people. Before the war, rice consumption was about 330 pounds per capita per year, compared to wheat consumption of about 30 pounds. They also were eating pearled barley. The diet, of course, was supplemented with vegetables, fruits, and seafoods. Consumption of red meat and dairy products was quite low.

When we started working in Japan in 1954, she was importing about 4 million metric tons of food grains per year. This consisted of 2 million tons of rice, 1.5 million of wheat, and 500 thousand of barley. The Japanese Government was then encouraging farmers to increase production of these cereal grains. Agriculture already was the most intensive of any nation in the world. Some people are surprised to learn that Japan has traditionally produced substantial amounts of wheat....about one-third of what she consumes. Wheat production has averaged about 1.4 million metric tons per year, compared to rice production exceeding 12 million.

Rice has been, and continues to be, the number one cereal food in Japan. The word for rice in Japan is "gohon," which also means "food" to many people. But conditions are changing. Per capita income has increased from about $150 per year after the war to over $580 per year today. Reconstruction has been complete for many years, and Japan is again one of the leading industrial nations. This has accelerated the movement of farm laborers to the cities, as in the United States. The people are becoming more westernized. Per capita consumption of rice has decreased from pre-war levels to about 260 pounds per year, while wheat consumption has more than doubled to some 60 pounds.

The efforts of the Japanese Government to expand the production of rice, wheat, and barley were markedly successful for the first 15 years after the war.

Acreage planted to wheat, however, began decreasing in 1952, and the total quantity produced was increased only through higher yields. It appears now that wheat production within Japan will tend to stabilize and decrease in the future. Land is being planted to more dependable crops, and precious acres are also being used for roads, homes, and industries.

There has been a significant increase during the past 5 years in the livestock industry within Japan. The expansion has been greatest in poultry for broilers and eggs. There is also a significant increase in the production of swine, with some increase in beef cattle and in dairy. This trend requires more feed, and has resulted in an expansion in the import of wheat for milling into flour and bran.

The import system. The Japanese government is the sole importer of all the wheat, rice, barley, and rye that are to be used for food. The Food Agency, a Department of the Ministry of Agriculture and Forestry, makes the plans and issues the tenders for import of these cereals. They maintain an office at Portland, Oregon--the only place in the world where they station a man to work on wheat. The Food Agency purchases wheat only from Japanese trading firms. The firms that may sell to the Food Agency have all been given an annual yearly allocation. The Food Agency then resells the wheat at a higher price to the Japanese flour millers. They charge about $30 per ton more than they pay on the world market for the wheat. The profit is used to help finance the cost of the price support program within Japan for rice and wheat.

Wheat for bran milling and flour. Earlier I mentioned that Japan imports wheat for feed purposes. Actually, this wheat is imported under a separate category from the wheat used for food. The wheat is milled into 55 percent bran and 45 percent flour. The mills obtain the wheat for bran and flour milling at lower prices than the food wheat.

For bran milling, the Japanese government has organized the flour mills into two groups. One group that includes the smaller mills is called "Senkan." These mills have usually received Manitoba No. 4 and 5 wheat. The larger, better financed mills are called the "Zosan" group, and they have received mostly Australian FAQ. In more recent years, the Senkan group has also received U.S. hard red winter wheat. This is obviously a subsidy program to help support the smaller mills. In 1951, there were some 3,000 flour mills in Japan. Today, there are still about 500 operating mills. Many of them of course are very small and use simple equipment.

History of wheat imports. Japan had two PL480 agreements with the United States for wheat imports under Title I. Many people have forgotten that Japan was once an aid-type country. The last wheat was imported in 1957 under PL480. Up to this time after the war, the United States was Japan's largest wheat supplier. After 1957, Japan began to purchase wheat on a global basis for cash. Most of the wheat she had purchased from the United States had been soft white wheat, which was available on the West Coast. The market was demanding higher-protein wheat for bread and for blending. The Japanese started importing large quantities of Canadian wheat in 1957, and this trend continued upward until 1961. In 1957 also Japan entered into a three-year bilateral trade agreement with Australia for wheat imports.

There was not a consistent pattern in the import of wheat into Japan after 1955. In that year, she imported 2,165,000 metric tons of wheat. This increased to 2,888,000 metric tons in 1956, and then decreased slightly to 2,167,000 metric tons in 1957. The decreases continued slightly then through 1959, and then imports increased slightly to 2,109,681 metric tons. The United States' share of the market started out at 1,046,000 metric tons in 1955 and decreased to a low point of 827,755 metric tons in 1959. In addition to the competition from Canada and Australia, the decreased imports from the United States were due to a continued increase in the production within Japan of rice, wheat, and barley. For example, Japanese rice production in 1960 amounted to 12,858,000 metric tons compared to 10,899,000 metric tons in 1956. The amount of rice and wheat that the Food Agency purchased from the farmers also increased substantially during this period.

There is another interesting story in the rapidly expanding market for wheat in the feed, bran, and flour milling category. For many years the United States was excluded from this market. Wheat imports for bran and flour milling in 1956 only amounted to 29,000 metric tons. By 1960, this had increased to 528,364 metric tons. This was a sizable market, amounting to over 18 million bushels. Up to this time, none of this wheat had been imported from the United States. This feed market has continued to increase, and during the 1964 Japanese fiscal year they imported 1,036,852 metric tons of wheat for milling into bran and flour.

The low point in USA sales of wheat to Japan was reached in 1961. That year, Japan purchased 813,649 metric tons from the United States compared to 1,326,306 metric tons from Canada, 424,510 metric tons from Australia, and 14,500 metric tons from Russia. During the last three and one half years, this picture, happily, has changed to our advantage. We have more than doubled our sales over this low point. During their fiscal year 1963, Japan purchased 1,707,885 metric tons of wheat from the USA, compared to 1,212,104 tons from Canada and 473,061 tons from Australia. For the first time since the aid programs following the last war, we had more than 50 percent of the cash wheat market in Japan. Last year we continued as the largest single exporter of wheat to Japan, and that position has been maintained through the first six months of this fiscal year.

Requirements of the market. When US wheat sales to Japan started to decline in 1958, we first thought this was due to a rapidly expanding bread market. This seemed to be the reason the Japanese were purchasing protein wheat from Canada. This was only partly true. The primary reason was to gain more flour strength for blending with domestic wheat for noodles and other products. The bread market has been expanding rather slowly.

In 1960, noodles were the largest single user of flour in Japan. The various types of noodles accounted for 44 percent of the flour that was milled. Bread accounted for 32, confectionery products for 14, and other products 10 percent. In 1964, noodles accounted for 43, bread 33, confectionery products 15, and others 9 percent. The total market has increased from 2,396,000 metric tons of flour in 1960 to 2,864,000 in 1964. There was an increase of 468,000 metric tons of flour during this period, but percentages for the different products stayed about the same.

The wheat-using industries within Japan are becoming more demanding in the quality of flour they use. Their plants are modernizing, and this requires a more uniform flour. Currently, however, in most cases the miller decides the quality of flour rather than meeting an order from the baker or noodle maker. In addition to changes in requirements of the market, there are other reasons for the import of different classes of wheat by Japan. We have already mentioned the bilateral trade agreement with Australia. Certainly balance of trade and the desire to export from Japan has influenced their purchases from other countries. For many years the Japanese believed that the United States could only supply a soft white wheat because this was the only wheat available in export position on the West Coast. This is one of the main reasons they started buying the bread-type wheats from Canada. These are high-quality wheats, with excellent milling yields; and once the miller became used to them, naturally, they encouraged the Food Agency to continue to buy them.

So far, I have talked generally about the situation in Japan and some of the changes. Now I would like to discuss our market development program and what influences we have had on expanding the total market for wheat foods and, in recent years particularly, in getting a greater share of that market to where the United States is once again the largest single exporter of wheat to this country.

The "soft sell." When we started the market development program in Japan in 1954, there was concern within the Department of Agriculture that we should not offend other world exporters that were members of the Western Alliance. Other world wheat exporters were at that time apprehensive that PL480 would replace cash markets. So, it was agreed that our objective would be to first expand the total market for wheat and wheat foods within Japan. Having created a bigger pie, then we supposedly could expect to get a larger share of it.

It took us almost two years, working with the Japanese Food Agency, to obtain approval to work in Japan with the industry groups. We opened an office there in the spring of 1956. A good deal of time was spent then on the organization of industry-wide associations to function as third-party cooperators. Market development projects were mainly directed toward educating the consumers to improve their nutrition and general health through increased consumption of wheat products. Taste appeal, convenience and food costs were also stressed. Fortunately, the Japanese government approved the program to increase consumption of wheat foods because wheat was less expensive than rice, and it would improve the nutrition and variety of the diet. Some of the early projects were the kitchen car demonstrations, the school lunch expansion program, the bakers' training course, and the distribution of printed materials promoting wheat products. These activities laid the groundwork and gave us acceptance with both the government and industry groups.

Moving to the "hard sell." It was probably necessary to go through the initial period of the soft sell. We were not sure ourselves what we could or should do. The US government did not want to offend the Canadians and Australians. Also, there was some risk of incurring the objections of the Japanese farmers themselves if we started pushing American wheat in competition with their own wheat and rice. It had become apparent, however, by 1959 that we were able to influence an increase in the total consumption of wheat foods within Japan. Unfortunately for us, however, our share of that market was decreasing. At this time we started to shift from soft sell to a hard sell program for US wheat.

The hard sell for US wheat required an entirely new approach to the market. It was obvious that since the Food Agency was the monopoly importer of wheat, our relationships with them had to be strengthened. We needed to improve our market intelligence to determine what their plans were and why they intended to buy certain classes of wheat from certain countries. We also needed to encourage the Japanese to import the protein classes of wheat from the United States in addition to our soft wheat. And, hand in hand with convincing the Food Agency to import the various classes of US wheat, there was a need to develop acceptance for it within the milling and user industries.

Jim Hutchinson, the present Director of our Tokyo office, moved in Japan in October of 1958 during this period of transition. He found it necessary to re-align and expand the Japanese staff to meet our new objectives. Fortunately, we found a Japanese named Paul Sone with considerable background in Japanese politics. He had little experience in agriculture, but he was dedicated and capable. He has now become a key employee in our office operation. Other staff members were hired to concentrate on strengthening our ties with the industry groups. We began to develop projects then that were keyed to the use of American wheat.

Some of these projects were carryovers from previous years, but they were given a new twist. The bakers' training program was modified to include lectures and demonstrations on the use of flours from US wheat. We were told that Japanese bakers were reluctant to use flour from US hard winter wheat because of its inferior baking quality. This opinion had been a repeated excuse for seeking cheaper export prices from the US on DHW by Japanese government officials and industrialists. A baking test and children's bread preference survey project was carried out during October of 1961 at 21 school bakeries in 23 prefectures. Approximately 38,500 children of 33 primary and junior high schools participated in the survey. Questionnaires for this bread taste preference survey were collected from every participating school. The result of the survey indicated that school children showed no distinct preference for bread made from Canadian flour.

A project to introduce new foods through department store exhibits was started in December 1959. The purpose was to popularize various noodle products and Western-style hotcakes. These new foods were to be made primarily from the types of flours milled from US wheat. Major flour-milling companies began producing and displaying consumer-sized packages of ready-to-mix hotcake flour. Training courses were set up with the Confectioners Association and the Dry Noodle Association. The purpose was to increase the import of US soft wheat into Japan through improvement of the product and expansion of the sales.

One of the most effective activities during this period was to bring government and industry trade missions to the United States. The Japanese learned from these trade missions that the United States had an abundant supply of wheat of other classes that could be used effectively in Japan in products that were now being made almost entirely from wheat imported from Canada and

Australia. We were working with the industry associations to encourage their use of the types of flour made from US wheat. At the same time, we were urging the Food Agency to import and test other classes of wheat. Small amounts of hard red winter 11.5-protein and dark northern spring wheat had been imported in 1956 and 1957. Hard red winter 11.5-protein was again imported in 1958 and 1959. This wheat was used for blending primarily into the noodle flours. The Japanese knew, however, that they could not import large quantities of the bread-type wheats from the United States until they were available in export position on the West Coast.

Rail rate reduction obtained. Activities were also going on in the United States to make it possible to have the various classes of US wheat available for export from the West Coast to Japan. Great Plains Wheat and the Department of Agriculture were successful in obtaining a rate reduction on wheat for export from the Great Plains in 1961. This was the key to opening the door to a new cash market. This is the year that we started making the big break-through on the hard-type classes of wheat to Japan.

The amount of hard red winter wheat increased from 175,529 tons in 1960 to 324,798 in 1961, 465,454 tons in 1962, 906,985 tons in 1963, and 947,724 tons in 1964. The imports were broken down into almost equal amounts of ordinary, 11.5, and 13-percent protein hard red winter. A new cash market had now been gained for some 30 million bushels of US wheat. Meanwhile, the market was still being maintained for the traditional sales of soft white wheat.

Importing a new class of wheat into Japan is not a simple matter. A policy decision has to be made first within the Food Agency favoring import of a new class of wheat. This involves many people. A trial shipment is then purchased and run through a series of milling and baking tests. Results of the tests are carefully analyzed by representatives of the Food Agency. Discussions are then held with the millers and other affected user groups. A resale price to the millers is determined, and negotiations are conducted with the exporting nation to determine the relative price level of the new class of wheat. Our office has played a significant part in all phases of the introduction of a new class of US wheat into Japan. This entire procedure may take from six months to more than a year.

Our program in Japan has expanded far beyond the original concept of administering projects contracted with local industry associations. We are now involved with the Food Agency and the US Department of Agriculture in setting prices and positioning stocks. The Food Agency expects us to have the answer to questions about US wheat and to handle trade complaints. They consider us in a similar category with the representatives of the Canadian and Australian Wheat Boards.

The Director in Japan is also responsible for our program in Okinawa, Taiwan, Hong Kong, and Korea. This area requires considerable travel. Robert Fondahn was assigned to our Tokyo office in September of 1963 to assist Jim Hutchinson. Both men are continuing there, and they work as an effective team.

The Canadian and Australian Wheat Boards have now opened offices with full-time representatives in Japan to compete with our program. Prior to this, neither board seemed too concerned about what we were doing. Australian soft wheat, however, all became restricted to a feed category at a lower import price. And in 1963 Canada was replaced as the largest exporter of wheat to Japan.

Imports of protein-type wheat from USA result in smaller sales of spring wheat from Canada. Representatives of both wheat boards concentrate mostly on representation and furnishing trade information. The Canadian Wheat Board, however, did make a cash grant of some $35,000 to the Japan Institute of Baking. Both boards sponsor trade teams from Japan to their countries. High ranking members of their boards also visit Japan at least annually.

Last year, Japan was the largest cash market in the world for US wheat. Over 40 percent of all US cash sales were purchased by this country. We were once again the largest single supplier of wheat to Japan. She purchased 1,575,000 metric tons during her fiscal year. During this current year, our goal is to increase these sales to 1,734,000 metric tons. We want to have at least 50 percent of the Japanese wheat market.

Two new classes of USA wheat are currently being tested in Japan. Preliminary results indicate a satisfactory performance for dark northern spring. We have been competitive in price. If we can maintain a suitably uniform quality, the total market for this class in Japan could increase to at least 15 million bushels per year. Tests have also been conducted now on durum wheat. The amount is not expected to be large but could equal at least 50,000 tons per year.

Mention was made earlier of the category of wheat imported into Japan for milling into bran and flour. The United States was excluded from this market until 1961. Since then, our sales have steadily increased until last year, when 357,326 metric tons were imported under this category.

The introduction of the new classes of wheat into Japan has been possible only with the complete cooperation of the United States Department of Agriculture, which has supported to the fullest extent the placing of these stocks in position on the West Coast. The Department has also made our wheat prices competitive through the necessary adjustment in export subsidies. Our relationship with the Agricultural Attache's office and the other members of the American Embassy in Tokyo has been excellent. Cliff Pulvermacher, Clancy Jean, and Joe Dodson deserve special recognition for their interest and support of our program. So a lot of people share the credit for what has been done in expanding so significantly the market in Japan for US wheat.

Quality problems. We do have quality problems. We have had complaints in the past about the lack of protein uniformity in our cargoes. A cargo of wheat is not unloaded all at one mill but may be unloaded at several points. If the cargo is not uniform, one buyer will get below-average protein and become unhappy. A more recent problem has been the low amylogram value of our white wheat, starting with last year's crop. This was due to unusual rainfall during the harvest season. Unfortunately, these conditions repeated themselves this year--and our problem may be even more severe. There was also one cargo of DNS which showed a low amylogram rating. Wet weather has also plagued Canada these last two years. This problem is one we share with others on the North American continent.

There has been some concern within Japan, too, over the change in varieties within our white wheat. The millers and users like White Club. They have adjusted to the Gaines variety, but they need about 200,000 tons per year of soft wheat with a maximum protein of 9 percent. Protein levels seem to be increasing slightly because of weather and fertilization.

Conclusion. Where do we go from here? Japan is the largest single dollar market for US wheat. Economic growth and development are bringing about a refinement in wheat usage to meet the demands of users and consumers. With this change, we are competing in a highly sensitive market that employs all tactics of international trade on a day-to-day basis to maintain the best importing position possible. This only means that US wheat is no longer in the general promotion aspect of acceptance per se but rather is competing for specific usages based on price, quality, and constant delivery of consistent quality. Everyone is well aware that the USA is working to erase an image of inconsistency in its marketing system which developed in the early years of international trade.

To be competitive in the strictest sense, we need a positive attitude in the many segments of our free trade system. In addition, our Wheat Associates' program must be designed to compete effectively with two major suppliers who can each concentrate on mainly one class of wheat. Because of the Japanese government system and controls in wheat trade, it is necessary for us to cover a broad area from the governmental level through the industry to the consumer. Our current goal is to assure the purchase by Japan, this marketing year, of at least 1.6 million metric tons. This amounts to 58,720,000 bushels--by far our largest cash market. The projects which we have underway and are planning for the remainder of this year are aimed at achieving this objective.

These projects with the various industry groups strengthen our position with the Food Agency. These projects involve us in working with many local people. Perhaps the key to our success has been the personal relationships we have developed with the government and industry officials. We are optimistic about the future. We could go into more detail on specific activities, but this would take much time--besides, we don't want to give away all of our secrets.

We are confident the program in Japan will continue to be successful. It will succeed if we can continue the close coordination and cooperation between wheat producers, the Department of Agriculture, and the grain trade in recognizing the needs of this market--and then doing whatever is necessary to meet these needs.

CHEMICAL PEELING OF GRAIN

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The process described here for peeling grains was reported at the Third National Wheat Utilization Research Conference. This report includes improvements made during the past year, notably in removal of bran in a water stream, in peeling other grains besides wheat and in modification of the effluent to facilitate waste disposal. A continuous automatic pilot plant for production of peeled cereals is now in operation at Albany, California. Free US licenses for this new process, invented by the authors, are available from USDA. The name WURLD, which is applied to all products, represents Western Utilization Research. It also suggests world-wide use. See Figure 1, page 20.

Cooked WURLD wheat. To provide an attractive new wheat food, wheat is parboiled by a mild version of the bulgur process before peeling. The peeled product has a slightly yellowish cast, compared with the creamy-white color of raw peeled wheat. This color diminishes on cooking because it is mainly due to the glassy transparent nature of parboiled grain. Cooked WURLD wheat can be steamed in only 15 minutes to a white, firm, kernel-form food. Some of the kernels partially open out during cooking. Very rapid final drying in 400°-500°F. air yields slightly puffed product which can be steamed in 5 minutes or even eaten dry.

Uncooked WURLD wheat. Another purpose of peeling is to provide a raw nutritious, white grain retaining its normal shape. Both uncooked and cooked WURLD wheat retain the protein values of wheat. The uncooked is rather shiny with a thin brown strip along one side where some of the bran remains in the crease of the grain. This product can conveniently be steamed in about 25 minutes to a firm, white, free-flowing edible grain, free of surface stickiness. This product has a pleasing texture. Because only 15 percent of the bran remains there is no sensation of toughness.

Table 1.--Wheat product characteristics

Property	Original wheat	Uncooked WURLD wheat	Cooked WURLD wheat
Color	Brown	White	Yellow-white
Colored bran content	9%	1%	0%
Cooking time	40 min.	25 min.	15 min.
Yield	100%	90%	85%
Density	64 lbs./bushel	61 lbs./bushel	40 lbs./bushel
Protein[1]	12%	11%	11%
Fat[1]	1.4%	1.3%	1.0%
Thiamine[1]	0.39 mg./100 g.	0.23 mg./100 g.	0.12 mg./100 g.
Riboflavin[1]	0.15 mg./100 g.	0.09 mg./100 g.	0.10 mg./100 g.
Germ	Present	Variable	Absent

[1] Analyses made by N. J. Tennis of this laboratory.

Table 1 compares characteristics of cooked and uncooked WURLD wheats at 14% moisture. The whitest peeled grains come from white common or club wheats. When peeled, red wheat appears only slightly colored in comparison with peeled white wheats.

Other cereals. Other grains which have been successfully peeled are barley, rye, rice, and oats. Barley, rye, and oats, however, do not provide quite as white a product as does wheat. Oats and barley yield a very bulky fibrous bran in addition to the peeled cereal. Both oats and barley, when peeled, can be advantageously milled to flour, especially for breakfast cereals.

WURLD barley yields 88 percent product compared with 55 percent from its alternative, pearled barley. WURLD rice, perfectly white, retains many nutrients normally lost in polishing and shows a much higher percentage of unbroken kernels. Some products are described in Table 2.

Table 2.--Other grain characteristics

Property	Pearled barley	WURLD barley	Polished rice	WURLD rice
Shape	Round	Elongated	Thin elongated	Thick elongated
Color	Gray	Yellow	White	White
Cooking time	35 min.	40 min.	25 min.	20 min.
Yield	55%	88%	70% whole grain	95% whole grain
Protein	10%	18% (Campagna variety)	6.0%	6.5% (Calrose variety)

Pretreatments. Some water-soluble nutrients (thiamine, nicotinic acid, pyridoxin) lie in or near the aleurone layer in wheat. It is known that when raw wheat and other cereals are soaked in water several hours at 140°F., nutrients diffuse into the kernel. Soaking is appropriate for wheat peeling, since the wheat is to be wetted anyway. Such soaking, however, does not contribute to the peeling process itself. It does seem to reduce loss of germ during peeling. For cooked WURLD wheat the wheat should be soaked in water one hour at temperatures rising from 135° to 180°F., held 30 minutes at 189°F., and then steamed at 212°F. for 15 minutes (Smith, Barta, and Lazar, Food Technol. 18: 89, 1964). The hot wet wheat is then peeled.

Heating. This step for cooked WURLD wheat takes place of course during preparation. For other grains some heating is also necessary. The grain must be at 180°F. or warmer to react with the lye. Since only a small amount of lye is used, the grain should be warm as well as the lye. One simple heating method is to pass steam through a layer of grain for several minutes. Grain temperature above 180°F. does not interfere with the peeling process. The heating has the additional advantages of inactivating enzymes and killing microorganisms.

Lye coating. For wheat, treatment with 25 percent sodium hydroxide at 180°F. for 3 minutes loosens the pericarp from the seed. For WURLD barley and WURLD oats, the same lye is used. For WURLD rice, 2.5 percent lye can be substituted. The lye reacts with components of the bran, making the used lye dark and viscous. It is therefore economical to wet the grain with just enough lye for the purpose rather than to submerge the grain in excess lye. To do this, we put the warm grain and 20 percent of its weight of hot 25 percent solids lye solution (8N-NaOH) into a ribbon mixer filled with live steam. The mixer must wet each kernel quickly and uniformly with lye and keep it that way for 3 minutes. Mixer design should insure positive control of treatment time by moving the grain uniformly through the mixer.

Peeling. The grain drops into room-temperature water after lye coating. The bath removes excess lye and limits lye penetration. This water is used also to wash off the excess acid in a later step. The slight acidity of this water helps to neutralize the lye and to reduce water consumption. The slurry of water and grain should then be pumped through a turbulent restriction to peel off the loose bran. This restriction can be a hydroclone, which augments the turbulence produced by the pump and serves to separate the heavy peeled grain in a little water from the light bran residue suspended in most of the water stream.

Acid rinse. At this stage, the peeled grain is often discolored by the action of the lye on the aleurone layer. After a short water wash, rinsing the grain 5 minutes in 1% acetic acid solution at 120°F. removes the color. The acid solution does not become foul or dirty. The same acid is used continuously, therefore, by adding about 1 pound of acid per 100 pounds of grain treated to make up for the acid neutralized by alkali in the grain. Rough handling of the grain is likely to rub off the germ at this stage. A screw trough conveyor transports it gently. If the germ is to be removed to increase storage stability, more violent mixing may be used here and most of the germ can be removed and some recovered. Sulfurous acid will whiten grain more than acetic. The SO$_2$ destroys thiamine completely, however, and there might be some difficulty in eliminating the SO$_2$ taste from the peeled grain.

Final rinse. The grain is lifted out of the acid rinse and washed with room-temperature water. This may be done countercurrently in another trough with a continuous screw, or in a drag conveyor under a water spray. The use of acetic acid does not demand a thorough final rinse, because remaining traces of the acid can be evaporated during drying.

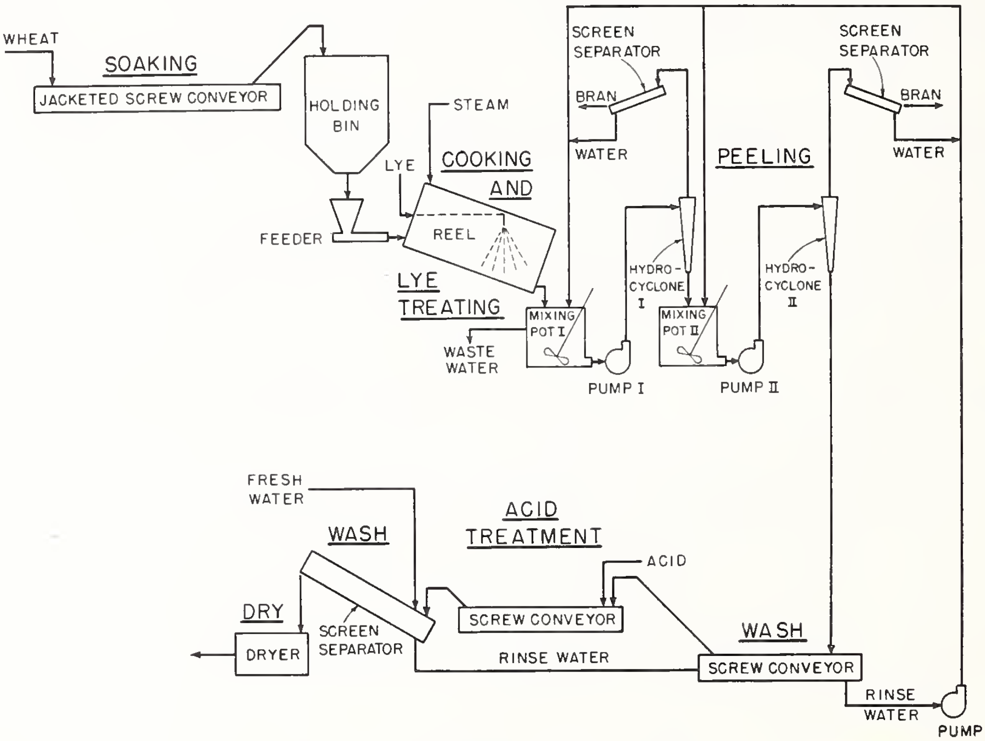

Figure 1. WURLD wheat plant.

Drying. When the grain is separated from the final rinse water, the kernels contain 30 percent moisture if uncooked and 50 percent if cooked. At this point, it may be desirable to spray on any solution of nutrients with which it is desired to enrich the product. To eliminate spoilage, drying back to 10-14 percent moisture should begin immediately. Warm air flowing through a mildly mixing bed of grain is an effective method. Many types of rotary dryers are satisfactory. On reaching 20-25 percent moisture, some type of ordinary grain dryer can be used. The bran collected at the flotation step can also be dried in air exhausting from the grain dryer.

Material requirements. Starting with 100 pounds of grain, 85 pounds of WURLD grain results, and 4 pounds of NaOH and 1 pound of acetic acid are needed. An exception is rice, which differs in requiring only 0.5 pound NaOH per cwt. and yields about 95 pounds of WURLD rice. About 1000 pounds of water are used and sent to waste. This waste water contains the residue of the lye and about 10 pounds of organic solids dissolved off the grain. The solid bran residue amounts to 5 pounds dry. This bran residue is almost entirely fiber. Energy requirements are small except for 250 cu. ft. of gas to dry each cwt. of grain.

Waste disposal. The effluent stream contains about 1 percent dissolved organic matter at a pH of 11.5, when incoming water use is minimized. The effluent pH can be reduced to 11.0 by using somewhat more water. When biological oxidation in a lagoon is necessary to reduce the BOD of the effluent, a pH between 11.0 and 11.5 is maximum for growth of organisms.

Costs. Lye and acetic acid are among the cheapest chemicals. Water, power, steam, and waste disposal requirements are modest, and depend on the equipment chosen. Equipment needed is simple and conventional, being confined to pumps, tanks, troughs, and dryers. Our estimates, in advance of practical experience, indicate a cost of about one cent per pound of grain peeled, assuming delivery in bulk.

BEVERAGE PRODUCTS FROM WHEAT

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"Hunger is a fundamental issue of our time, and the treatment we give it in the next few years will affect the survival of our species and the well being of individuals." This quote from The Hungry World, published by the Royal Bank of Canada, points to a problem with which we are all familiar. This worldwide hunger is such an urgent problem that it has claimed the attention of thinking men throughout the world.

There are two trends in our thinking about the hunger problem that are important to us. The first is the emphasis placed on feeding children. As you may know, malnutrition during early childhood results in shorter life, decreased resistance to infectious disease, impaired physical and mental growth, and decreased productive capacity. Medical evidence indicates that the physical and mental retardation is irreversible.

The Agency for International Development has estimated that in the developing countries there are 667 million children under 15 years of age. By 1975 this figure will become 815 million. Currently, some 269 million children are suffering serious malnutrition. This figure can rise to 329 million in 10 years. Food for Peace donations are reaching about 15 percent of the 7-to-14 year group with supplemental milk and grain foods, but only 2 percent of the preschool group are reached. The second trend is toward improving the donated foods nutritionally, as exemplified by addition of vitamins A and D to the nonfat dry milk used in the Food for Peace programs.

What do these facts imply with respect to wheat and wheat products? I think it is fairly clear that wheat will continue to be used in great quantity as grain, flour, bulgur, and rolled wheat. However, these products are not especially suited for very young children who, if indications are correct, will be getting more and more attention. When one thinks of children, one immediately thinks of milk. Indeed, nonfat milk is being supplied in great quantity. However, there is a very short limit to the supply, and other products must be sought. Vegetable protein sources are frequently mentioned. Why not wheat? One reason why wheat is not thought of is that no wheat product is available which can be used as a milk-like product. No wheat product has been devised in which the insoluble gluten protein has been made soluble or dispersible. Yet wheat has a lot to recommend it. It is available in abundance. It has a reasonably high protein content, and it seems to be free, or essentially free, of undesirable flavors and antinutritional factors.

Let us compare wheat with some other plant sources of protein. Table 1 shows cost of protein in various food sources. These figures are from an article by J. C. Abbott, of the Food and Agriculture Organization of the United Nations, which appeared recently in Food Technology. Defatted soy flour, fish, flour (now called fish protein concentrate), skim milk powder, and chick peas are the only items which provide protein at a lower price than wheat flour, as calculated here. Of course, this table does not tell the whole story. Some items are at much higher protein level than others, and part of the price represents processing costs to achieve the particular end product--for example, soybean protein isolate. Some products might be credited for values other than protein. Further, nothing is said about processing costs to put each in a usable form for human consumption, which may, for example, require removing or altering undesirable flavor and removing or inactivating antinutritional factors. New efficiencies in processing and other factors would undoubtedly alter the relative costs and desirability of these materials. We feel certain that wheat products can play a large role, not only as a vehicle for other materials but as a source of a great deal of the food protein that will serve the needs of preschool children as well as those older.

The type of final product desired for most convenient and inexpensive mass use would probably be a storage-stable dry powder, easily dispersible in liquids and stable when dispersed. It should be wholesome, palatable, low in fiber content, and bland in flavor. In many ways it would resemble dry milk powder, but it would not necessarily be milk-like. For example, it could be used as a soup base. The nutritional value of the starting materials should be preserved during processing and supplemented as necessary to increase protein level, to enhance biological value of the protein, and to provide levels of vitamins and minerals that might be recommended.

Table 1.--Prices of protein from various sources

Product	Price of protein content cents per kg.
Skim milk, powder	51
Chick peas	62
Beans	78
Wheat flour	68
MPF (soybean)	104
Defatted soy flour	40
Protein isolate, soybean	97
Lypro (peanut), Britain	117
Coconut, desiccated	191

Most of the rest of my presentation will deal with the processing of wheat materials to achieve these objectives. At the outset, there are problems that must be overcome when starting with a wheat flour, for example. First, most of the protein in flour is insoluble. It will have to be modified in some manner or other to make it soluble, or at least dispersible. Next, the raw wheat starch is insoluble. Even if it were gelatinized to render it somewhat soluble, its thickening power is so great that only very dilute solutions or dispersions would be possible. Therefore, starch must be modified. For many applications, it will also be desirable to decrease starch in order to increase protein content. Fortunately, the types of processing that will accomplish these objects are simple and straightforward. Our principal task is to select the best combination of steps to get a product meeting the specifications and to keep costs to a minimum. Let us now discuss some of the processing itself.

Dr. H. N. Draudt of the Purdue Research Foundation under a contract sponsored by our laboratory studied, among other things, the solubilization of the protein of wheat flour by various enzymes. He concluded that pepsin is the most satisfactory because it almost completely solubilizes the protein while degrading the protein least of any of the enzymes studied. The latter is important for two reasons: (1) maintenance of the nutritional quality of the protein during processing and subsequent storage and (2) stability of the product flavor and color toward nonenzymatic browning. Therefore, in our subsequent studies of processes for a milk-like product from flour we have used pepsin to modify the protein.

The pepsin-acid method. One scheme for producing a milk-like product is shown in Figure 1. We call this the pepsin-acid method. The flour may be air classified, high-gluten, or even ordinary baker's flour. It is first slurried with two parts of water; the pH is adjusted in the range of 1.0 to 2.5; a small amount of pepsin is added; and the digestion is allowed to proceed at room temperature for two to four hours. During this time upwards of 90 percent of the protein is digested and rendered soluble. The slurry is then centrifuged to yield two fractions: (1) the dense solids which are principally prime starch and (2) the solubles plus squeegee starch. The protein is found principally in the solubles. The squeegee layer is a highly hydrated gummy layer made up principally of pentosans but with some small-granule starch, protein, and other components. This layer is also referred to as amylodextrins (see Figure 2).

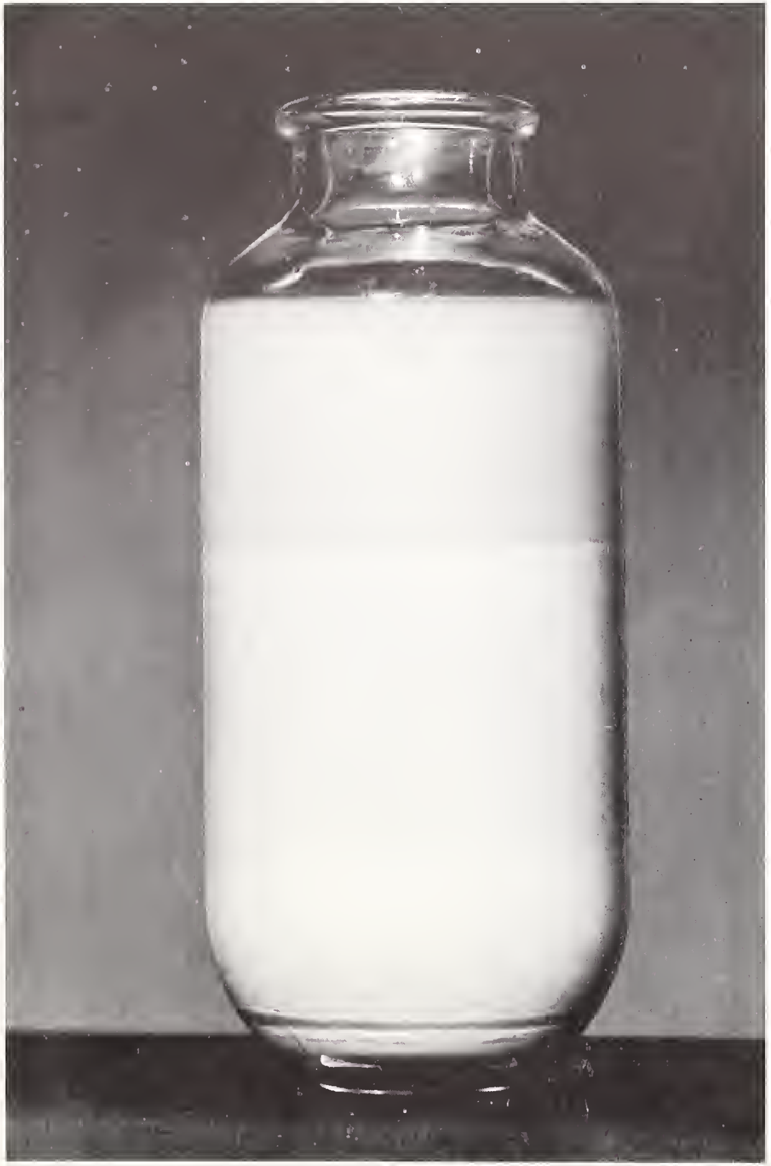

Figure 2. Centrifuged slurry showing fractions (see text).

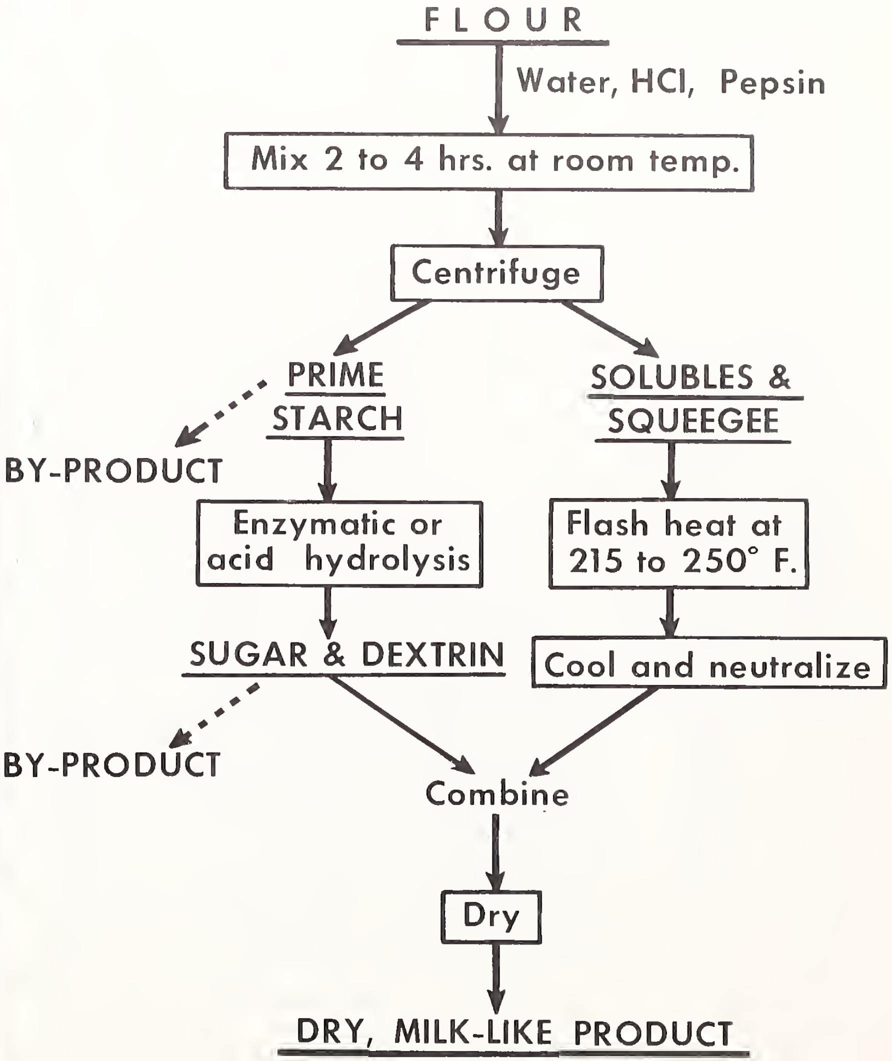

Figure 1. The pepsin-acid method.

The proportion of material divided between the two fractions varies with the flour used. For air classified flour about 45 percent of the solids and 90 percent of the protein are contained in the soluble and squeegee layer. For high-gluten flour (15 percent protein at 14 percent H_2O) the proportions are 48 percent of the solids and 93 percent of the protein.

The solubles and squeegee, still in the acid condition, next are flash heated. Flash heating might consist of two minutes at 215°F. or a few seconds at 250°F. This step removes the raw wheat flavor and gelatinizes and hydrolyzes the starch and pentosans. The heating can be varied to control the viscosity and dispersibility of the final product, within limits. The heated liquid is next cooled, neutralized, and dried. A product between 40 and 45 percent protein is obtained when air-classified flour is used. When a high-gluten flour having about 15 percent protein is used, the product has about 32 percent protein. The protein level can be adjusted to any value below these by addition of soluble carbohydrates (sugars and dextrins) obtained from the prime starch by hydrolysis. The portion of this fraction not needed becomes a commercially valuable by-product. We have so far dried the products by drum-drying or freeze-drying. We believe spray-drying could be used and might be the most attractive commercially.

Products of this process are fairly easily dispersed. The reconstituted product is quite bland, creamy white, and smooth. As I indicated earlier, variation in the process can be used to control the viscosity, dispersibility, and other product characteristics. The protein efficiency ratio (PER) determined on one sample indicated only slight loss in nutritional quality due to processing. The product seems to have good stability in the dry state against development of rancidity.

The amylase-pepsin method. Another processing scheme we have used is shown in Figure 3. This we call the amylase-pepsin method. In this scheme, again, the flour may be of various kinds. It is slurried and treated with an enzyme, a bacterial amylase, at 160°F. for 15 minutes to 2 hours. This hydrolyzes the starch to sugars and dextrins, making them soluble. As a consequence, the slurry thins greatly. The slurry is cooled and acidified to pH 2.5, pepsin is added, and digestion is allowed to proceed for one hour. Pepsin digests the protein, so that almost all of the flour is now solubilized. Centrifugation removes a small quantity of insoluble branny material. This amounts to about 1 percent of the total, but it is very important that it be removed. Otherwise, it imparts a grittiness to the reconstituted beverage. The solubilized flour is neutralized and then boiled for 10 minutes to remove the raw wheat taste. Finally the mixture is dried.

This product is highly dispersible, creamy white, and bland to slightly sweet in flavor. The viscosity and sweetness can be controlled somewhat by the concentration of amylase and time of digestion. The protein efficiency ratio (PER) of one drum-dried sample showed a substantial decrease from that of the starting flour, illustrating that care must be exercised to prevent losses in protein quality when starch solubilization precedes the protein hydrolysis.

Stabilization. These two processing schemes demonstrate rather well that commercially feasible methods can readily be used to modify the initial undesirable properties of starch and gluten to yield easily dispersible, dry products.

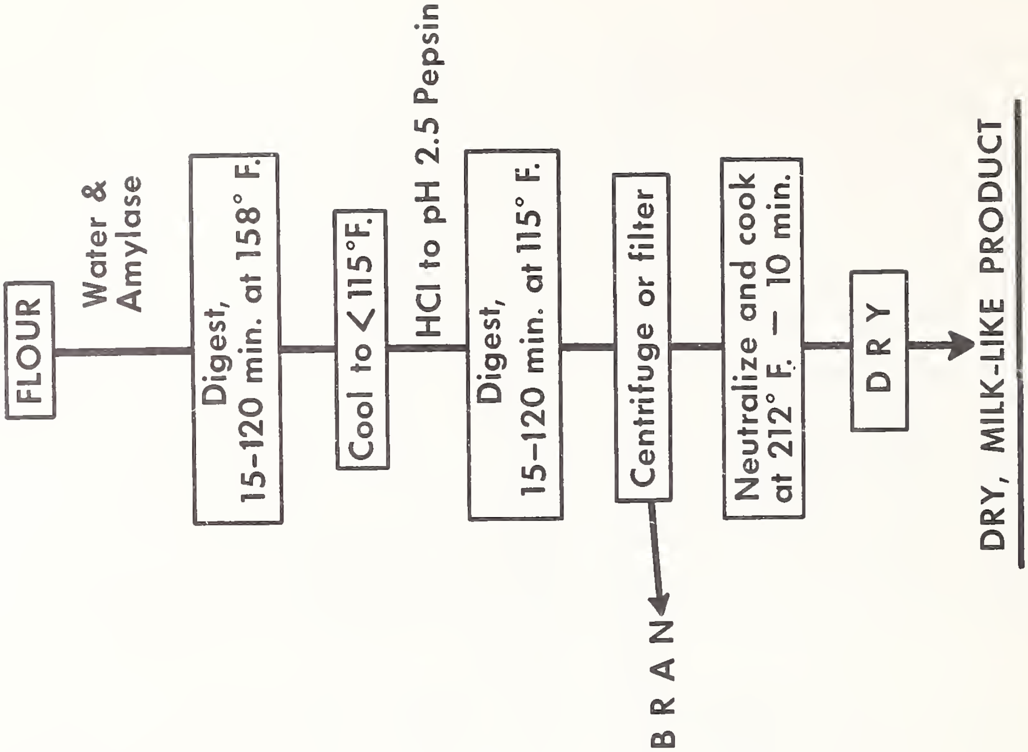

Figure 3. The amylase-pepsin method.

Other combinations of the several processing steps are also possible and may have advantages over those just discussed. Once the big hurdle of dispersibility has been overcome, another aspect becomes primary. This is stability in both nutritive values and in organoleptic properties during anticipated storage and distribution under unfavorable conditions.

Stability during processing concerns chiefly the maintenance of protein nutritive quality. Certain combinations of various processing steps are better for protein quality retention than others. Particular care must be taken to minimize heating of materials when they contain increased amounts of reducing sugars and free amino groups resulting from the enzymatic breakdown of starch and protein. The production of reducing-sugar groups is especially of concern, because the epsilon amino groups of the sensitive and vital amino acid, lysine, are as free to react in the intact protein as in the partially hydrolyzed protein. Lysine is perhaps the key amino acid because at the outset flour proteins contain none of it to spare. Other essential amino acids are also susceptible to damage. As mentioned earlier, processing can be accomplished with no serious damage to protein quality by several of the processing combinations we have studied to date.

We have also found stability of the fatty materials in the final product to be affected by processing. The results have been somewhat irregular, but enough favorable results have been obtained to make us confident that the problem can easily be avoided without reliance on antioxidants.

Quality supplements. In the first of the processing schemes outlined in some detail a few moments ago, the level of protein in the final product can be regulated over a rather wide range. In the second processing scheme, the level of protein in the final product is about the same as that in the starting material. Addition of extra protein from other sources would be desirable. In either product, an increase in biological value will be needed to meet the nutritive requirements of infants. Such enhanced quality can easily be obtained by the addition of suitable sources of protein comparatively high in lysine content. Such sources will include protein from oilseed meals, fish protein concentrate, and nonfat dry milk. With the latter, the wheat-based beverage products can serve as an effective and economical extender of the supply of milk protein that is none too plentiful for the tremendous needs overseas. The blandness of the wheat products makes them excellent for blending with milk powder.

In considering quality supplementation of the wheat-based beverage products, the value of the synthetic amino acids, lysine and threonine, should not be overlooked. Surprisingly small amounts are required to bring the protein value of the wheat products up to that of casein. Even at today's fairly high prices for the amino acids, the cost is small. It would also drop quite quickly and substantially if a good-sized demand were to develop.

Another source of high-value supplementary protein is found in good quantity in wheat mill feeds, used in animal rations. At the Wheat Utilization Research Conference in Peoria two years ago, Dr. George Kohler and Mr. Frank Hepburn thoroughly reviewed the high nutritive value of these proteins. Since then, we and others have been studying methods to recover this protein so that it can be used in food products. By either wet or dry separation methods we can obtain 30 to 60 percent of the protein of bran as concentrates suitable for use in milk-like or other food products. The processing methods again are simple, so that we are optimistic that this protein can be competitive with other sources of supplemental protein for the milk-like products. Nearly five million tons of wheat mill feeds, containing some 800,000 tons of protein, are available each year. Tapping this vast store would result in higher returns for what is now virtually a waste and would have attendant economic benefits for all concerned.

Two other types of fortification appear to be desirable and quite easily accomplished. First, it will be quite simple and quite inexpensive to add whatever minerals and vitamins may be desired. In addition to the B-vitamins already plentiful in many wheat products, stabilized vitamins A and D can be added just as they presently are to the nonfat dry milk powder in the Food for Peace programs. Appropriate mineral salts, notably those of iron, calcium, and phosphorus, can be added for a pittance. Finally, if desirable, stabilized vegetable oils can very easily be added to the final dry product to provide extra calories and nutrition similar to that obtainable from whole fresh milk.

Flavorings. Before closing, I would like to give some added emphasis to the essential blandness of the products. All the products we have made retain a faint but distinctly wheaty flavor, which is not the least bit unpleasant. Moreover, it blends with added flavorings quite well. To recipients not accustomed to fresh animal milks, the unflavored wheat milks would very likely be highly acceptable. However, addition of flavorings especially liked and readily available in particular world regions would almost guarantee high acceptance. We have found the wheat beverage bases to be excellent when flavored with chocolate, malt, coconut, or banana. Many others are, of course, equally feasible. Sugar, for example, is plentiful in many world regions and can be used to increase acceptance. Another exotic flavorant might be the rose water so highly thought of in India.

So far we have stressed the beverage use of the new wheat products. We also think they can serve equally well as soup bases. For example, we have flavored them with chicken broth or with tomato paste to make excellent high-protein cream-type soups. Again, seasoning suitable to each recipient country or locality can be used to enhance acceptance. The seasonings could be added in manufacture or at time of use. In fact, we visualize that eventually much of these types of product will be made overseas because the processing is inherently so simple that adaptation should be relatively easy. Perhaps the only real edge processors in this country might retain is the lower cost of drying of the fluid products that I have just described.

To review very briefly in closing, I have described some of the progress we have achieved. Processing has been worked out by which flours and other wheat materials can be converted to solubilized forms. Products made entirely from wheat or supplemented with other proteins can be produced for infants or older children alike. Many combinations of steps, starting materials, supplemental materials, flavorings, and nutrition-building additives are possible at costs that can make the products competitive with other materials for any market or use level. Much work remains to improve all of the processing and to lower costs.

CARRYING CAPACITY OF UNITED STATES WHEATS FOR EUROPEAN WHEATS

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The earliest settlers from Europe introduced wheat to America. From colonial days until about 1870, the USA produced soft wheat that would be regarded by today's standards as "weak" in baking quality; but in 1873, hard red winter wheat was introduced in the Great Plains area by immigrants from Russia. From the very first plantings of "Turkey Red" by Mennonite immigrants, it found favor with American millers and bakers. However, a soft red winter type still is grown extensively in Western Europe.

Europe was importing wheat from America before 1900. The hard red winter wheats, and later the hard red springs, were most desirable. Europe can produce rye to a better advantage than wheat; blending of rye with wheat is a very old practice. However, in recent years, production of rye has decreased steadily and wheat has increased. Today over 50 percent of western Europe's rye is grown in Germany, and rye breads are still very popular there, but the trend is toward more white bread. Aside from the universal use of breakfast rolls made from wheat flour, Germans are learning to eat toasted white bread. Switzerland now requires only 3 percent rye in its mill blends, which is hardly noticed in their bakery products. All other European countries mill 100 percent wheat and prefer white breads.

Wheat production has increased since World War II. Each country wants to be as self-sufficient as possible. New varieties have been developed to improve their agronomic features and baking qualities. Yields have increased. In the last few years, The Netherlands has averaged 70 bushels per acre; Belgium, Denmark, and England average over 60 bushels, Switzerland and Germany average over 50 bushels, France averages over 45 bushels, and Austria and Sweden average about 40 bushels.

In the last 40 years western Europe, including the British Isles, has more than doubled its wheat production. Except in England, European farmers have guaranteed incentive prices to increase wheat production. The EEC (Common Market) countries have a graduating levy system to control prices of all imported wheat above the local wheat prices. The other countries either maintain high tariffs or control imports by government purchases. Thus millers are required by one system or another to grind all the local wheat available.

In the last three years, western Europe has reached a peak production of about 1.5 billion bushels, with imports of approximately 500 million bushels. The United States' share of the imports has been about 20 percent or less than 100 million bushels.

Those figures show what could happen if sizable areas should be converted to other crops in Europe. Demand increases each year for feed grains. Corn is grown extensively in southern France, Italy, and Spain, but most of Europe is not suitable for corn. Sorghum grains, however, could be adapted to wider areas than corn. Test plantings are being made there; in time sorghums will find a place in Europe. Protein supplements are needed, and soya beans may replace some wheat acreage. Germany is now importing beans to be extracted in her plants.

Every present indication is that wheat production has peaked in Europe. Other crops will replace some wheat acreage and imports of wheat should increase.

Wheat project. About a year ago a project was started at Kansas State University under contract with the Western Utilization Research and Development Division, U.S. Department of Agriculture, to determine the maximum carrying capacities of US hard red winter wheat flours in blends with weaker European wheat flours. We would like to report our procedures and developments to date. We of course use statistics and one source is Economic Research Service of USDA.

Our first concern was to obtain proper samples from European countries, and also representative samples of US winter and spring wheat of protein levels typical of wheats available for export to Europe. We asked a number of US grain terminal elevators and export companies to supply 100-pound samples at various protein levels. The samples were blends of many lots. We received 20 in all. After milling small lots, analyzing their physical and chemical properties, and test baking, we were able to group them into three samples of hard red winter wheat with protein levels of 11.3, 12.1, and 13.7 percent on the basis of 14 percent moisture. One sample of yellow hard winter testing 10.0 percent protein was included to compare with European samples. We also added one sample of dark northern spring testing 13.7, obtained by blending two composite samples drawn from wheat ready for export.

Three-hundred-pound samples were obtained from England, Holland, Belgium, France, Germany, Sweden, Switzerland, and Austria. All were from milling companies and were drawn from their mill blend of local wheat. All were graded by the Federal Inspection Office in Kansas City. The samples from five countries graded soft red winter. The samples from two countries graded hard winter and one graded dark northern spring. We had not expected this spring wheat sample, which came from Switzerland. Ninety percent of the Swiss wheat is soft red winter. Recently, they have been growing spring wheat at higher elevations, supported with a government incentive premium.

Milling. After preliminary tests, we milled the samples on a Miag Multimat experimental mill. It processes a continuous flow of wheat at 90 pounds per hour of soft wheat to 120 pounds of hard. The mill has three breaks and five reductions. Soft wheat was tempered at 15 percent moisture, hard wheat at 16. Yields of the European samples ranged from 72.6 percent and 0.45 ash to 76.3 percent and 0.54 ash. United States hard wheat samples gave comparable yields of 73.9 to 75.1 percent and 0.46 to 0.53 ash.

Baking. Baking tests were made by the AACC standard pup-loaf method to determine optimum mixing and oxidation requirements. Special bakes were also run to test several European test baking formulas. These differ from the American test formula in several aspects. Optimum mixing is not mandatory; in fact, judged by our standards, the doughs are generally undermixed. The French dough formula calls for flour, sodium chloride, yeast, and water. Since most European flours have a high diastatic activity, this lean formula produces an acceptable bread, by French standards. The Germans like to add to their doughs about 2 percent sugar and 1 percent shortening, which improves shelf-life of bread. French bread is eaten the day it is baked and usually within a few hours of baking. It becomes too tough to be eaten the next day.

Continental Europe, except Holland, does not allow use of any chemicals. Consequently, mills do not bleach or treat flours, and bakers do not use additives. Recently ascorbic acid has been allowed and is finding favor with the European baking industry. Ascorbic acid and bromate have similar effects in dough.

Both England and Holland allow bleaching and oxidizing chemicals. Their baking formulas are more nearly like America's. They also bake some bread with powdered milk and label it "milk bread". Both pan and hearth bread are made, but pan bread predominates. Their pan bread, however, is more compact than American bread, partly from use of less water (stiffer doughs) and partly from less pan volume per weight of dough. Differences in European bread formulas are being considered in baking test comparisons using blends of US wheat flour with European flours. Blends of 10, 20, and 40 percent US flour with each European flour sample will be examined and evaluated.

We are now obtaining European wheat samples from the 1965 crop. The 1964 crop was above average in both yield and quality; 1964 ripening weather permitted the wheat to mature properly. Weather conditions in 1965 were different. A cool summer and wet fall prevented proper maturing and caused much sprouting before harvest. This is not unusual in Europe, and therefore wheat from the

1965 crop should be compared with wheat from their 1964 crop. Also blends of the 1965 crop and US samples will be studied.

Wheat comparisons. Figure 1 shows farinograph curves for each flour sample. The top six curves represent soft red winter wheat samples from Europe.

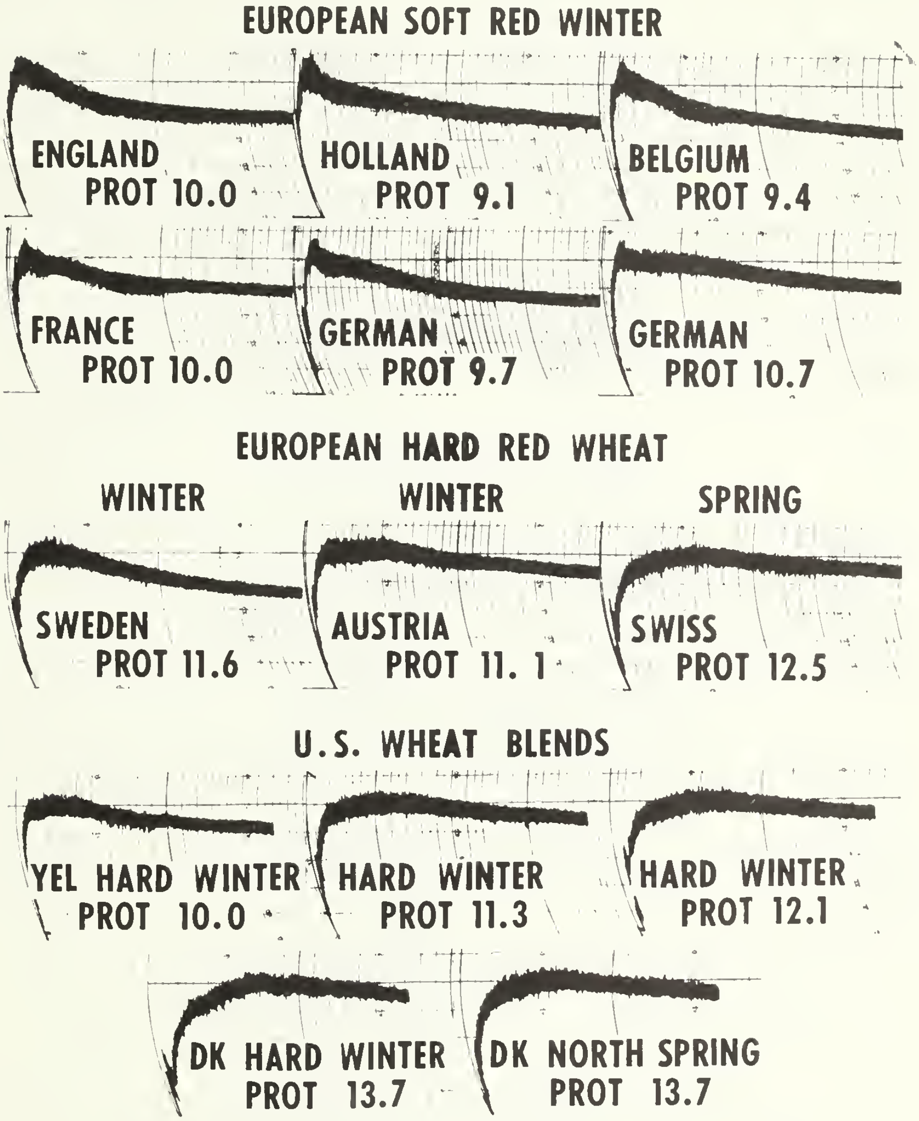

Figure 1. Farinograms for various samples.

We obtained two samples from Germany because of wide variation among its districts. One German sample is 1 percent higher in protein and has a little stronger curve. The other German curve is very similar to the English, Dutch, Belgian, and French curves. The two hard winter wheat curves from Sweden and Austria should be compared with the US yellow hard winter at 10 percent protein. The United States sample has better quality, borne out in baking tests. The spring wheat sample from Switzerland shows a good curve for 12.5 percent protein wheat, which was confirmed by baking.

Under those curves are five curves of US wheat blends. The first, for yellow hard winter, should be compared with the two European hard wheat curves. The other winter wheat curves become progressively stronger with higher protein. The fifth curve of dark northern spring, of course, is stronger than the curve for the Swiss spring wheat.

Table 1 shows the analysis of wheat and flour from the English sample. Note particularly the loaf volume and bread score of this sample and on each succeeding table. The 1964 English wheat crop was 135,855,000 bushels, about 40 percent of their requirements. Five-year average US imports by England is 16,150,000 bushels or about 10 percent of England's imports. Canada supplies about 50 percent of England's imports. Most US wheat imported by England is low and medium protein winter wheat.

Table 1.--English wheat sample

Grade 1 soft red winter--test weight 61.5

Wheat analysis		Milling - baking	
Protein[1]	10.0%	Flour yield	75.3%
Moisture	14.4	Protein[1]	9.2
Ash of wheat[1]	1.61	Moisture	12.9
Sedimentation	20	Ash[1]	0.48
		Absorption	54.4
		Loaf volume (cc.)	730
		Baking score	76

[1] Moisture basis is 14%.

Table 2.--Dutch weat sample

Grade 2 soft red winter--test weight 59.7

Wheat analysis		Milling - baking	
Protein[1]	9.1%	Flour yield	74.9%
Moisture	10.6	Protein[1]	8.5
Ash of wheat[1]	1.44	Moisture	12.5
Sedimentation	19	Ash[1]	.49
		Absorption	53
		Loaf volume (cc.)	687
		Baking score	75

[1] Moisture basis is 14%.

Table 3.--Belgian wheat sample

Grade 3 soft red winter--test weight 58.6

Wheat analysis		Milling - baking	
Protein[1]	9.4%	Flour yield	73.9%
Moisture	12.3	Protein[1]	9
Ash of wheat[1]	1.47	Moisture	12.2
Sedimentation	17	Ash[1]	.46
		Absorption	54.2
		Loaf volume (cc.)	715
		Baking score	76

[1] Moisture basis is 14%.

Table 4.--French wheat sample

Grade 2 heavy soft red winter--test weight 63.0

Wheat analysis		Milling - baking	
Protein[1]	10.0%	Flour yield	76.3%
Moisture	12.1	Protein[1]	9.1
Ash of wheat[1]	1.47	Moisture	12.4
Sedimentation	20	Ash[1]	.44
		Absorption	55
		Loaf volume (cc.)	737
		Baking score	77

[1] Moisture basis is 14%.

Table 5.--German wheat sample

Grade 1 soft red winter--test weight 60.7

Wheat analysis		Milling - baking	
Protein[1]	9.7%	Flour yield	75.0%
Moisture	11.3	Protein[1]	8.7
Ash of wheat[1]	1.55	Moisture	12.6
Sedimentation	18	Ash[1]	.47
		Absorption	59
		Loaf volume (cc.)	727
		Baking score	76

[1] Moisture basis is 14%.

Table 6.--German wheat sample

Grade 2 soft red winter--test weight 60.0

Wheat analysis		Milling - baking	
Protein[1]	10.7%	Flour yield	74.1%
Moisture	10.7	Protein[1]	10.3
Ash of wheat[1]	1.64	Moisture	12.3
Sedimentation	31	Ash[1]	.51
		Absorption	60.2
		Loaf volume (cc.)	740
		Baking score	77

[1] Moisture basis is 14%.

Table 7.--Swedish wheat sample

Grade 3 hard winter--test weight 61.5

Wheat analysis		Milling - baking	
Protein[1]	11.6%	Flour yield	72.6%
Moisture	11.6	Protein[1]	10.9
Ash of wheat[1]	1.48	Moisture	13.1
Sedimentation	43	Ash[1]	.48
		Absorption	54.4
		Loaf volume (cc.)	755
		Baking score	75

[1] Moisture basis is 14%.

Table 2 shows the analysis of the sample from Holland. Holland's 1964 crop totaled 26,163,000 bushels, also only 40 percent of her requirements. Some years Holland produces only 25 percent of her wheat needs. The five-year average of US imports is 16,500,000 bushels, or 42 percent of Dutch imports.

Percentagewise, Holland is our best customer. She uses winter wheat at all protein levels, and also considerable United States hard spring wheat.

Table 8.--Austrian wheat sample

Grade 3 heavy hard winter--test weight 63.4

Wheat analysis		Milling - baking	
Protein[1]	11.1%	Flour yield	75.0%
Moisture	12.4	Protein[1]	10.2
Ash of wheat[1]	1.65	Moisture	12.5
Sedimentation	38	Ash[1]	.47
		Absorption	57.2
		Loaf volume (cc.)	735
		Baking score	77

[1] Moisture basis is 14%.

Table 9.--Swiss wheat sample

Grade 1 heavy dark north spring--test weight 61.8

Wheat analysis		Milling - baking	
Protein[1]	12.5%	Flour yield	72.4%
Moisture	12.7	Protein[1]	11.9
Ash of wheat[1]	1.58	Moisture	12.9
Sedimentation	65	Ash[1]	.53
		Absorption	66
		Loaf volume (cc.)	897
		Baking score	86

[1] Moisture basis is 14%.

Table 10.--US wheat sample

Grade 1 yellow hard winter--test weight 62.8

Wheat analysis		Milling - baking	
Protein[1]	10.0%	Flour yield	73.9%
Moisture	11.3	Protein[1]	9.1
Ash of wheat[1]	1.53	Moisture	12.8
Sedimentation	22	Ash[1]	.44
		Absorption	59.6
		Loaf volume (cc.)	782
		Baking score	80

[1] Moisture basis is 14%.

Table 11.--US wheat samples

Optimum baking data

1. Hard winter 11.3 protein		3. Dark hard winter 13.7 protein	
Flour protein[1]	10.4	Flour protein[1]	12.8
Loaf volume (cc.)	825	Loaf volume (cc.)	922
Baking score	78	Baking score	85
2. Hard winter 12.1 protein		4. Dark north spring 13.7 protein	
Flour protein[1]	11.2	Flour protein[1]	13.1
Loaf volume (cc.)	870	Loaf volume (cc.)	1007
Baking score	85	Baking score	90

[1] Moisture basis is 14%.

Table 3 shows the Belgian sample. Belgium's 1964 crop totaled 33,065,000 bushels, 70 percent of their requirements. Since the crop varies with weather, they may import as much as 50 percent in some years. The five-year average of US imports is 4,250,000 bushels.

Table 4 represents the sample from France. Her 1964 crop totaled 508,446,000 bushels, twice as much as France's domestic requirements. Yet France imports about 10 percent of her needs, mostly durum. However, about 3 percent is high protein wheat, some of which has been hard winter the last few years. France, an exporting nation, would like to sell most of her wheat in the European market but other European countries don't want it. As you know, much French wheat has been sold to China the last two years.

Tables 5 and 6 represent the two German samples. Individual mill requirements depend somewhat on which kind of German wheat is more readily available. Germany's 1964 crop was 190,500,000 bushels. That was good for Germany and covered about 75 percent of her needs. However, imports in Germany may be as high as 40 percent some years. The five-year average of imports from USA is 11,500,000 bushels or about 14 percent of imports. When her imports are high, Germany will buy considerable soft red winter and ordinary hard winter. Most German millers prefer Canadian spring for their strong wheat.

Table 7 is Sweden's sample. Sweden's 1964 crop was 39,095,000 bushels. This covered her entire requirements, plus a little for export, probably to Germany. However, some years Sweden is short because of sprout damage. When Russia had wheat to export, Sweden was Russia's best European customer. The five-year average of imports from USA is about 300,000 bushels.

Table 8 is the Austrian sample. Her 1964 crop totaled 27,576,000 bushels. Her wheat varies from very poor soft red winter to very good hard red winter running 13 percent protein or more. This sample is about average. Austria imports about 5 percent of her needs. High protein Manitoba, US spring or 14 percent protein winter are bought on bid by the government and distributed to the mills.

Table 9 is the sample from Switzerland. Spring wheat constitutes about 10 percent of her production. Her 1964 crop totaled 13,705,000 bushels, a little more than 50 percent of her requirements. For security reasons, the Swiss government maintains a six months' reserve. Fifty percent local and 50 imported wheat (usually Manitoba) are purchased and held for three years. One-third is sold to the mills and then replaced each year. Annual imports from USA have averaged about 3,339,000 bushels the past five years.

Table 10 is for US yellow hard winter, the wheat we used in baking tests as a standard for low protein wheat. Table 11 gives a brief report of the other four US wheat samples. The whole project involves a study of the carrying capacity of these four US wheats with the European samples.

Summary. Europe is a cash market. Taken as a whole it purchases about one fourth of the wheat needed. One-half billion bushels are purchased each year. Two World Wars have increased the production of wheat in Europe. Production has been pushed beyond economic justification; now however, economic changes are putting greater emphasis on feed grains which Europe can grow better than wheat. Thus, US exporters will need to know blending wheat requirements of each European country. Within a few years Europe may be buying a billion bushels per year, double her present purchases. The US share of Europe's market will depend to a large extent on our ability to produce wheat to meet specifications of these individual importing countries.

THE VALUE OF WHEAT AS FOOD FOR MAN

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The importance of wheat in man's diet has been recognized from time immemorial. The psalmist stated that the Lord giveth "bread which strengthens man's heart." In his commentaries on this part of the 104th Psalm, Matthew Henry in the 17th century wrote, "Here is bread which strengthens man's heart and therefore called the staff of life." Other English writers of the same era such as Jonathan Swift also referred to bread as the staff of life. In a similar manner, the word bread has been intimately related to the etymological origins of the word nutrition. Dr. Todhunter (J. Am. Diet. Assoc. 46:120, 1965) pointed out that the first reference to a word related to nutrition is in the writings of Andrew Bovrde, the physician to King Henry VIII. The quotation cited is: "This matter doth go moche by educayon or the bryngyng up of the people, the which have been nourished or nutryfyde with such bread."

Times are different now, you say, and people can afford foods other than bread. The substitution of meat for bread as the economic situation improves has been recognized for centuries. Thomas Fuller, an English physician in the 17th century was aware of this when he wrote:

They that have no other meat
Bread and butter are glad to eat.

Today, many people are still impressed with the philosophy expressed by Fuller. In our opulent society, we have progressed to the point that we consider our food economy as meat oriented. We frequently hear about the steady reduction in US per capita consumption of wheat products. This trend has engendered in some people the thought that wheat may eventually disappear from the American diet. If this were so, then why devote any attention to the role of wheat in human nutrition?

Let us look at statistics for a moment to see if we can secure an indication of the situation as it exists today and what it might be in the years to come. The latest report of the Department of Agriculture on "Food Consumption in the United States" indicates a linear reduction in the yearly per capita consumption of wheat flour from 214 pounds in 1910 to 118 in 1960. Since the latter date, the same source indicated that the consumption of wheat flour has leveled off at close to 115 pounds. Over the same period, the per capita consumption of all skeletal meats has increased from 135 to 139 pounds. If this small increase surprises you, remember that while veal and lamb products showed a decrease in consumption, beef increased.

The slight increase in meat consumption becomes somewhat larger when it is related to the total food consumption. In the 50-year period following 1910, the per capita consumption of all foods declined from 1,617 to 1,420 pounds. On this basis, meat now makes up a larger fraction of the American diet and wheat makes up an even smaller fraction.

A large-scale survey of actual consumption in this country was carried out by the Agricultural Research Service of USDA in 1955. (Another study is nearing completion.) That study showed that for all households studied, grain products provided about two and a half times as many calories as meat, poultry, and fish combined. Even as recently as ten years ago, wheat and cereal products were still an important item in our diet. A similar picture emerges when we look at the favorite food of the teenager--the hamburger. Despite the fact that practically all emphasis is put on the meat, the bun still provides about two-thirds of the calories. Wheat will continue to pay an important role in the diets of all mankind. There is nothing to suggest that the present situation in this country will be drastically altered.

In many other countries, wheat makes up an even greater part of the civilian diet. As the population throughout the world continues to increase at a rapid rate, and as available agricultural land is taken over by our burgeoning suburbia, it is very possible that the importance of wheat may increase, thus reversing the trend of the past half century. The basis for this statement is the differential efficiency seen when wheat products are consumed directly by man as compared to the conversion of plant products to meat or other animal products. We needn't stress the fact that from a caloric standpoint, wheat produces five to six times as much food as animals.

The statement is frequently made that a diet based on wheat requires supplementation with animal products. This, so the reasoning goes, should be apparent to everyone familiar with the laboratory animal studies which showed wheat to be deficient in lysine. The deficiency of this amino acid can be overcome by the inclusion of animal products in the diet.

Such reasoning initiated research at Michigan State University dealing with bread in the human diet. This study resulted from an Iranian student's resolve to secure the training which would permit her to improve the nutritional condition of her countrymen. When she indicated that bread provided three-fourths of the daily caloric intake of Iranian peasants, she was advised to carry out animal feeding trials with bread to which such "protein" foods as legumes and skim milk powder had been added.

Weanling rats were fed rations containing 90 percent dried bread, along with minerals and an adequate vitamin mixture. In the preliminary studies, commercial white bread was compared with bread air mailed from Iran. Subsequent studies involved the addition of 7 to 15 percent of dried lentils or 4 percent of skim milk powder to the ration containing the Iranian bread. These supplements increased weight gains by as much as two- to three-fold. Calculations indicated that the basal bread diet contained an inadequate amount of essential amino acids for good growth in the weanling rat.

Similar calculations were made for adult human beings. J. H. Browe _et_ _al_. (_Am. J. Clin. Nutr_. _9_: 478, 1961) and the publications of Food and Agriculture Organization of the United Nations were used in estimating the bread consumption of people in the Middle East. These reports suggest that people in that part of the world receive 70 percent of their caloric intake from bread and other cereal products. On this basis, we calculated the amino acid intake that an adult would receive if he consumed a 2500-calorie diet with 70 percent of the calories from bread. The white flour in such a diet provides all the essential amino acids well above the levels reported necessary for adults. This means that the essential amino acids for adults should be provided by a diet in which 70 percent of the calories came from bread, regardless of the composition of the remaining 30 percent of calories.

There were no reports in the literature of a study carried out to assay the adequacy of the proteins in bread prepared from white flour, a leavening agent, salt, sugar, fat, and water. The closest approach to such a study was that of R. C. Darling _et_ _al_. (_J. Nutr_. _28_: 273, 1944). They reported that healthy young men could be maintained in nitrogen equilibrium when fed a diet restricted to provide 50-55 grams of protein "very little of which was of animal origin."

Hegsted _et_ _al_. (_J. Lab. Clin. Med_. _31_: 261, 1946) found that a low protein diet was unable to maintain nitrogen equilibrium in adults. Half the protein in their diets came from bread, the remainder from vegetables. They suggested however that if healthy adults consumed diets relatively high in cereals, they should remain in protein equilibrium. However, no test of this hypothesis was carried out.

Widdowson and McCance (Med. Res. Council Spec. Rpt. 287, London, 1954) fed diets providing 51 to 73 grams protein per day to 9- to 14-year-old girls. Eight to 11 grams of the daily protein intake were of animal origin, with the remainder from bread and cereal. The primary purpose of that study was to evaluate the quality of the different types of flour used in baking the bread. All children in the study grew at normal rates. There were no differences among the children in the various study groups. These investigators concluded that under the conditions of their study, the degree of extraction of the flour or its enrichment with minerals and vitamins had no effect on the children.

The only study in which bread was the primary source of protein has been reported in abstract form. Rice, Flodin, and Schuman (_Federation Proc_. _14_: 13, 1960) found that college students showed increased nitrogen retention when lysine was added to bread which provided 95 percent of the protein intake. The bread was made with 4 percent skim milk powder.

In view of the dearth of information on the effect of a diet in which bread was the primary source of protein, a study was undertaken with college men. Funds for the work were provided by the U. S. Department of Agriculture. Twelve healthy male students were selected from 40 volunteers. They were chosen on the basis of age, approximation of body weights to the values listed in standard height-weight tables, freedom from disease as evidenced by a general physical examination, and a normal psychological profile. The study consisted of a 21-day control period during which the subjects received a "typical American" diet but restricted to provide 72 grams of protein per day. To prevent monotony, there were 7 diets, each of which contained some meat, milk, eggs, and other animal foods.

The control period was followed by 50 days of experimental diet which provided 67 grams of protein with 90 percent of this coming from wheat flour and the remainder from fruits and vegetables. Again, 7 different diets were used. Additional calories were available as whey-free butter, jam, jelly, and hard candies. Bread and rolls were baked each day. They were made from an enriched all-purpose flour, vegetable shortening, sugar, salt, yeast, and water. An extra meal was prepared each day for analytical purposes.

Throughout the study, 24-hour urine and stool samples were collected. Analyses of these samples and the diets indicated that during the control period the men were in negative nitrogen balance which approached equilibrium at the end of the third week. During the first half of the experimental period, the subjects showed an average daily loss of 100 milligrams of nitrogen; for the second half, there was an average retention of 1380 milligrams.

Throughout the study there were fluctuations in body weights of individual subjects. However, for the entire group, there was no change in mean body weights. Although body weights did not change, body specific gravities did, as determined by underwater weighing. This indicated that the body fat content of the subjects was lower at the end than at the start of the study.

The reduction in body fat content suggests an improvement in the physical condition of the subjects during the study. That this did occur is borne out by the reduction in pulse rates while the men ran at 6 mph. on the treadmill for 10 minutes. Not only was there a reduction in the pulse rates during running, but the rate returned more rapidly to normal at the end of the experiment than at the start. This improved physical condition probably resulted from the increased spontaneous activity indulged in by the subjects with the advent of summer-like weather toward the middle of the experimental period. This increased activity is largely responsible for the increased intake of supplements which brought the calories up from 2,983 during the control to 3,320 during the experimental period.

There were no significant differences in the excretion of amino acids, creatinine or uric acid. Venous blood samples secured at intervals throughout the study showed no changes in total serum protein, albumin-globulin ratios, hemoglobin, hematocrit or serum glutamic-oxalacetic transaminase activity. There was, however, an increase in serum glutamic-pyruvate transaminase activity during the experimental period. The significance of this change has not been established.

During the experimental period there was a dramatic reduction in serum urea levels. The average serum urea level was 13.1 milligrams per 100 milliliters at the midpoint and 16.9 at the end of the control period. Both values are within normal limits. At the midpoint of the experimental period, the urea was down to 7.3 milligrams and at the end it was 6.8. The two latter values are definitely below normal and pose a question when an attempt is made to explain them. It is recognized that a low protein intake reduces urea synthesis in the body and this is reflected in lower serum and urinary levels. In this study, however, there was no significant change in dietary protein level; there was only a change from a mixed animal-plant protein intake during the control period to a predominantly wheat protein intake during the experimental period.

The changes in the serum urea levels are mirrored, to a minor extent, in the urinary levels. This is especially true toward the end of the experimental period when urea made up a smaller fraction of the total urinary nitrogen excretion. The reduction in urinary urea levels appears to lag behind the reduction in serum urea. The reduction in serum urea level has been confirmed in a 5-day study during which bread was the major component of the diet. Within 48 hours after starting the bread diet, the serum urea levels of the subjects were on their way down. The influence of wheat and perhaps other plant proteins on blood urea levels deserves further study, since this may provide a basis for a new dietary approach to some forms of chronic kidney disease.

CURRENT STUDIES ON FLOUR COMPOSITION AND BAKING QUALITY

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It is probably safe to say that attempts to correlate flour composition with baking quality have kept more cereal chemists at work than any other single problem in the field. The usefulness of flour in any of its many applications quite obviously depends upon its composition. The question, however, is how does flour behavior depend upon composition. A great deal of important information has been collected over the years, and it is serving very usefully in the milling and baking industries, here and abroad. The trouble is, however, that available information is simply not yet complete enough. Too many puzzling and expensive questions remain. Research on composition goes back many years, but has been increasing at an especially rapid rate for the past several years. When baking was a hand operation fluctuations in flour quality were taken care of quite easily. Certainly, then as now, different flours were better suited for types of baked goods, but marked variations would still be found among lots of flour. However, if a dough was sticky, the baker would just add a little more flour; if it was a little tough, he would add more liquid or shortening or increase mixing time. Obviously, in that situation, the need to control baking quality of flour was minimal.

With the advent of large-scale, mechanized bakeries, however, the need to control baking quality became very great and, since the adoption of continuous mix processes, this need has been escalated to a nearly "critical" status. Under these modern conditions it can be very expensive to modify processing operations in order to compensate for overly long mixing times, insufficient tolerance, or stickiness of the dough or batter. In addition to the need for uniformity, continuous mix processes also require flours that can withstand severe mechanical treatment and high temperature and still recover sufficiently to permit the development of the thin-walled cells in doughs which will retain gas for proper loaf volume. Providing the baking industry with flours that meet such stiff requirements is no easy job for either the wheat grower or the flour miller because, as yet, there is no simple way to fully predict performance qualities of any given flour. The performance of a flour in any type of process or product is the sum total of so many complex factors that it is understandable why simple solutions have not yet been found. So long as this problem remains we can only approximate a flour's performance without conducting a complete baking test. Aside from the cost of such testing on every lot of flour, this requirement works a hardship on plant breeders who strive to develop ever better varieties, as it necessitates time-consuming production of large quantities of seed. Even then, years may have been wasted if flour from the new variety proves to be unsuitable for baking.

Another facet of the same problem concerns the use of maturing agents to improve flour performance. As you will know, most flours produced from hard red winter wheats require treatment with artificial maturing agents to fulfill their optimum baking potential. Without this treatment, such flour is at a great disadvantage in competition with most spring wheat flours. This is, indeed, found to be the case in countries such as West Germany, where the use of artificial maturing agents is either prohibited or restricted to levels at which they are ineffective. It is known that, given sufficient time, flour will mature naturally. However, this process may be lengthy and, even worse, quite variable, so that it is not economically feasible to rely on natural aging. What is intriguing here is that a natural system obviously exists, and if we can learn how it operates we may be able to develop methods to reproduce that process. If nature can do this with oxygen and natural enzyme systems, maybe we can use them to speed up the process without relying on other chemical agents.

The prediction or assessment of the suitability of various wheats and flours for uses other than in baked products is also important to us. As you heard yesterday from Dr. Morgan and Mr. Shepherd, we are not standing pat on food uses. While seeking to expand consumption of conventional wheat products, we are also developing many novel wheat foods. Such research demands information on the effects of composition on wheat and flour properties.

These, briefly, are the major reasons for research into the correlation of chemical composition with flour quality. Now, how are we going about this work?

Of the constituents of wheat flour, the proteins have been, and still are, receiving the greatest attention from cereal chemists. Those who attended last year's conference at Manhattan, Kansas, will recall the excellent presentations on wheat proteins by Dr. Pomeranz of Kansas State University, by Director Dimler of the Northern Utilization Research Division, and by Dr. Lawrence of Washington State University. Their talks illustrated the broad scope of wheat protein research under way at various laboratories. The emphasis on proteins is both understandable and logical. Aside from the nutritional importance of flour protein, it is known that the physical and structural characteristics of doughs, batters, and all baked products made therefrom are, in large measure, determined by the nature of the flour proteins. The critical question is how the proteins exert their effects. Only parts of the answer have been obtained.

An early assumption was that, since flours vary widely in functional properties, it might be expected that their proteins would also differ widely. To be sure, quantities of protein do differ widely among wheat varieties, types, crop years, and lots. Preliminary study, however, indicated that qualitatively the proteins of all samples were very much alike, and even the relative quantities of protein groups were similar. These findings led us to use a technique which is very sensitive to differences in the chemical or structural nature of proteins. This technique was pioneered by one of our Public Law 480 grantees, Dr. Pierre Grabar of the Pasteur Institute in Paris. Dr. Grabar combined immunochemical reactions with gel electrophoresis to develop the technique now known as immunoelectrophoresis. When ordinary gel electrophoresis is used, the proteins in an extract of flour are separated by differences in size or electrical charge of the protein molecules. Under the influence of an applied voltage the proteins move as bands and can be visualized after electrophoresis by treatment with a staining dye. For any given set of conditions, that is, buffer system and pH, voltage applied, etc., it can be assumed that if two wheat proteins move in the same direction and at the same rate, so that they are found at the same location in the gel, then these proteins may be similar, if not identical.

Immunochemical reactions are based on the following circumstances: when a protein is injected into an animal, such as a rabbit, after a few weeks substances called antibodies are produced in the bloodstream--as part of the animal body's defense mechanism. The rabbit's blood can then be used as an antiserum for the specific protein which had originally been injected. As such, when mixed with a solution of that protein, the antibodies of the blood will react with the protein and form a precipitate. This antigen-antibody reaction is fairly specific, and is the basis for immunization against many diseases of humans and animals.

In a difficult piece of work, Dr. C. C. Nimmo of our laboratory used the techniques of immunoelectrophoresis to determine whether the proteins of wheats showed any qualitative differences. He selected, for comparison, the hard red spring variety Selkirk and the durum variety Mindum. These are widely differing wheat types and, so far as could be determined, they have no immediate, common ancestry. Extracts of the proteins of Selkirk and Mindum were electrophoresed and then challenged with a mixture of both Selkirk and Mindum antiserums. Matching precipitation arcs were formed for every protein of both wheats, with the possible exception of a minor component which is present in Mindum but apparently absent from Selkirk. Limited experiments with the gluten proteins of these wheats indicate similar identity.

It is true that all of this evidence is, in a way, only circumstantial. All of the proteins have not been isolated in pure state, analyzed, and shown to be identical for these two wheats. However, the odds would be very great against different proteins having both the same electrophoretic mobility and identical immunological response. Therefore, while we cannot yet be absolutely certain that qualitative differences do not exist, there is a high degree of certainty to this conclusion.

At first glance these findings may seem to be discouraging, and it is a fact that, if they are correct, this will complicate our research considerably.

But it is possible that this information was just what we needed to direct us to other aspects that may be more productive. For example, we know that, in their native state, most plant proteins probably exist in a complexed form. This is to say that they do not really exist as "pure" naked proteins in wheat endosperm, or elsewhere for that matter. We have found much evidence to show that proteins occur complexed with lipids, with polysaccharides, with both lipids and polysaccharides, with metallic ions, indeed, even with other proteins. Any number of such possible combinations may, and probably do, exist. As versatile, functionally, as proteins may be alone, this versatility is increased many-fold when they are complexed with other types of molecules. Like a high school boy getting his first automobile, the proteins can go places and do things they never could before. If we could study the proteins in their complexed forms, maybe we could, too.

As a matter of fact, we have been proceeding in that direction for some time. For example we and others have found that lipids have an important influence on the baking qualities of flours despite being present in relatively small amounts. Thus, phosphorus-containing lipids, particularly, must be present if gluten is to exhibit its normal plastic flow properties. The way that these phospholipids participate in the flow properties of gluten is not yet known, but lipoprotein complexes are known to exist in many important biological structures. About four years ago, in another laboratory, a model was proposed for gluten structure which postulated a slip-plane formed of sheets arising from the complexing of phospholipid material to protein through salt-like linkages. Recent work in our laboratory, however, indicates that phospholipoprotein complexes are more likely to arise through combinations of protein with phospholipid and with metallic ions to form three-way complexes. Studies using model compounds have demonstrated that these phospholipid-metal-protein complexes are unusually stable and therefore likely to persist in doughs in preference to other arrangements. Other data from this study favor strongly the theory that the lipid materials exist and function in the form of micelles or self-contained small aggregates, rather than as sheets. Although this work is fundamental and not yet far along, it points up the need for examining in minute detail some of the proteins and lipids, not as individual but as complexed substances in flours and doughs.

Another phase of our research which may shed light on complexed proteins has also been under way for some time. The sulfhydryl groups of flour proteins have been of interest because of their great chemical reactivity, for example, with oxidizing agents such as oxygen of the air and compounds of the type that are well known flour improvers, including potassium iodate and bromate. Sulfhydryl-containing proteins are also of interest because of their apparent relationship to the mixing properties of doughs. One concept that has received much consideration is that of sulfhydryl-disulfide interchange; that is, disulfide is the sulfur-containing bridge between protein molecules or spots on the same molecule, and sulfhydryl is the split and very reactive ends of the bridges after they are broken. We know that wheat proteins contain both of these types of sulfur groups. During mixing disulfide groups may be split to form new sulfhydryl groups and sulfhydryls may be joined to form disulfides. Thus, old linkages may be broken and new ones established with the result that the physical properties of the proteins may be profoundly altered. Dr. R. J. Dimler, at the last two of these utilization research conferences, has discussed in some detail how these groups form and break up to affect the properties of gluten proteins.

Experimentally increasing the quantity of free sulfhydryl groups in doughs has been shown to weaken the doughs quite dramatically. Increasing the number of disulfide linkages has the opposite effect. Farinograph mixing curves have been run on doughs to which have been added increasing amounts of a chemical which blocks the sulfhydryl groups, preventing their conversion to disulfide bonds. Time to maximum dough resistance was shortened, the maximum resistance increased, and dough breakdown rate greatly increased.

Recently Mr. D. K. Mecham in our laboratory has been studying the fate of sulfhydryl groups during dough mixing in a nitrogen atmosphere. When dough is mixed in air, it has been shown that free sulfhydryl groups rapidly disappear, presumably because they are oxidized to disulfides. Therefore, it was thought that the formation of disulfide bonds was necessary for proper dough development. Under nitrogen, however, doughs develop normally while free sulfhydryl groups show a slow but steady increase, which is related directly to the protein content of the flour. This appears to indicate that the role of sulfhydryl groups in dough development must be reexamined. Apparently dough formation involves an initial degradation of the natural network of long protein chains in wheat flour, rather than a buildup of the network as it exists among the glutenin molecules of gluten.

These sulfur-bonding groups may also be involved in protein-protein interaction, or complexing, in another way. Just as disulfide bonds may link chains of a single kind of protein, they may also join different proteins together into a different, complexed molecule. For example, albumin or globulin molecules might very well become linked to gluten proteins to change the behavior of the whole mass. This type of combination among wheat proteins must be thoroughly investigated before we can understand relationships of composition to quality or performance.

Still another group of complexed proteins is beginning to receive attention because of possible influence on the baking quality of flour. These are the so-called glycoproteins or sugar-containing protein complexes, in which carbohydrate polymers, or polysaccharides, are linked to protein molecules. For some time now, protein chemists have complained about the stubborn carbohydrate impurities in protein preparations isolated from wheat. There has been speculation as to whether these substances are really impurities or parts of conjugated molecules which would be considered to be glycoproteins. Recent studies indicate that, at least in some instances, protein and carbohydrate are chemically bound, not just physically associated. Work in this field was rekindled by reports from Neukom at the Swiss Federal Institute in Zurich, and is now under way also at the American Institute of Baking in Chicago, in the Wheat Research Unit of C.S.I.R.O. in Australia, as well as in our own laboratories.

Thus far, at least one glycoprotein, obtained from a water extract of flour, has been shown to be very susceptible to oxidation, whereupon it forms a gel. Since dough mixing is carried out in a highly oxidizing situation, there may be some connection here to the viscoelastic nature of dough. Additionally, Tracey's group in Australia has shown strong evidence for the contribution of these polysaccharide components of flour to bread loaf volume. Much more evidence is needed, of course, before the role of polysaccharides and/or glycoproteins can be determined, and we are working toward that goal.

In a completely different area of research, current studies on the enzyme systems of wheat offer promise for providing important information related to flour quality, especially with respect to the mechanism of flour aging. Working under a grant from our Division, Professor Mark Stahmann of the University of Wisconsin has been studying the oxidizing and reducing enzyme systems occurring naturally in wheat and flour. A wide variety of such enzymes were shown to be present in whole wheat, flour, and several mill fractions. The one enzyme with perhaps the greatest amount of activity was found to be a lipoxidase. As you might guess, this enzyme speeds the oxidation of lipids, especially long-chain fatty acids such as oleic, linoleic and linolenic, which by the way are all present in wheat. Of special interest in these studies was the finding that, with the four different wheat flours assayed, there was a very marked relationship between lipoxidase activity and mixing tolerance in the Farinograph. Where the activity of the enzyme was high, tolerance time was low, the dough breaking down quickly. Flour with low lipoxidase activity, on the other hand, exhibited a much higher mixing tolerance time. While these findings are of great interest, their broad generality has yet to be established; it is too soon to jump to any conclusions. However, it is pleasant and often profitable to speculate, so let me do so now. In the work I described on lipoprotein complexes forming through metal binding, it was found that long-chain fatty acids help to stabilize these complexes. Also, lipoproteins are probably involved in the plastic flow properties of gluten. If a lipoxidase enzyme were to speed the breakdown of fatty acids, this could lead to breakdown of lipoprotein complexes. This in turn could reduce the plasticity of dough, and the result could be a lowered Farinograph mixing tolerance time. This is as yet only very wild speculation.

In trying to summarize some of the current research in this field it is unavoidable that much previous work cannot be described in the detail that it deserves. A great deal of very important information about wheat composition has accumulated through the years and good use has been made of it by the milling, baking, and other industries. As the needs of these industries for greater product uniformity and performance have increased, the need for more and better information becomes more acute. For we find that, despite all the information that has become available, millers and bakers keep asking ever tougher questions that we can't answer--they seem to have a knack for that. It has become necessary to dig even deeper into the kernel of wheat and to use the very latest scientific methods that are available to come up with the kind of information that is needed. We are fortunate that such rapid strides are being made in methodology and instrumentation that we can dig deeper and recognize the riches when we strike them.

As this information becomes available, we in the Department of Agriculture attempt to bring it promptly to the attention of those who can make the best use of it, namely growers, processors, and users. This meeting is an example. Others are the meeting last night with the Technical Committee of the Millers' National Federation and the three-day meeting at Albany last month with the American Bakers' Association Technical Liaison Committee. These annual meetings are not just one-way affairs. Rather, we also receive better insight into the problems so that we can direct our research toward solutions.

MOLD TOXINS IN FARM PRODUCTS

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In the past few years there has been an increased recognition of the importance of preventing mold damage in maintaining quality of feeds and foods. Mold damage has long been a factor in the Federal market grades of farm commodities. More than a specified minimal amount of such damage relegates a shipment to sample grade and a much lower price. Odor, flavor, and appearance are all usually adversely affected. Feed value may also be reduced if damage is extensive. Moreover, over the years isolated cases of animal poisoning have been traced to moldy feeds.

Recent interest stems from a major outbreak in England in 1960. The disease, called "Turkey X", caused losses in a considerable number of turkey poults, but ducklings as well as partridge and pheasant poults were affected. The same disease was later shown to affect in some degree other farm animals, such as calves and swine.

The disease was traced to a moldy peanut meal imported from Brazil and fed as a protein supplement. Chemists then succeeded in separating the toxic substance and it was demonstrated that it was produced by the mold Aspergillus flavus which also was found in the meal. The toxin was named aflatoxin by taking an "A" from Aspergillus and "fla" from flavus and combining "afla" so formed with toxin.

The toxin was found to be extremely potent, a lethal dose for a duckling being 20-50 millionths of a gram. Translated to ounces, this means that one ounce, properly distributed, would kill a million ducklings. This impressive toxicity and evidence that aflatoxin also caused liver tumors was the basis for widespread concern.

But not all molds are harmful. In fact, for centuries molds have been used by man in preparation of the food he eats. This has been true particularly in Japan, China, and other countries in the Orient where molds have long been used to develop desirable flavors and textures in soybean-based foods such as miso, natto, and tempeh. This practice has not been limited to the Orient. Many highly flavored European and American cheeses owe their flavors to molds used in their preparation.

We are dependent on a mold for the most widely used and first discovered antibiotic, penicillin. Many other antibiotics are produced by molds of the streptomyces group. Useful products elaborated by molds also include the vitamins B_2, B_{12}, and beta-carotene, and also organic acids and various enzymes. I should add, however, that the molds used in the preparation of foods are a selected few. Most of the thousands of molds that occur in nature are undesirable in foods because of disagreeable odors, flavors, or antinutritional factors that they produce.

With this assurance that not all molds produce toxins, I will give you a few more examples of those that do. Indeed molds are much like mushrooms--many are good to eat, but you had better know which one you're eating. The comparison is a good one since mushrooms and molds are closely related genetically.

Cases of serious mold poisoning in cattle and sheep grazing on forage (pasture) have been reported in New Zealand and Australia. The animals poisoned show symptoms of photosensitization described as facial eczema. The disease also entails severe liver damage.

Cattle on fescue winter pasture in our Southern States frequently develop a disease called fescue foot. This is characterized by a gangrenous condition of the hooves and tail extremity. Recent work at our Western and Northern Divisions indicates the disease is caused by a mold growing on the fescue rather than by a toxic constituent of the fescue plant. It is interesting that fescue foot occurs only in the winter when temperature alternates from warm to cold.

There are other examples where such conditions appear to have been responsible for toxin-producing molds on grains. In several regions in Russia during World War II, the disease known as alimentary toxic aleukia was widespread and frequently lethal, especially in 1944 when food was so scarce that many people could get food only by searching for grains that had been in the fields all winter. A species of fusarium mold was found to be the toxin producer. A freezing-thawing cycle especially favored their growth and in the field was necessary for toxin production. Toxicity was highest in samples of wheat, then millet, then barley.

Rice grown in the Orient sometimes is infected with yellow rice disease. The mold that causes this disease is Penicillium islandicum and the yellow color is associated with a toxic substance called Luteoskyrin which caused illness in man. The relatively high frequency of "yellow" rice in the years immediately following World War II caused the Japanese to be extremely careful about the rice they imported. Indeed at that time our Southern and Western Divisions, in cooperation with Japanese scientists, examined tens of thousands of grains of rice produced in the South and the West for the presence of the Penicillium islandicum mold. On the basis of the findings, the Japanese government removed its restrictions on the purchase of US rice.

The literature also reports cases of poisoning in animals fed moldy corn. Indeed, molds isolated from such toxic grain, and subsequently grown in pure cultures, have been shown to produce toxic factors. There is thus ample evidence that moldy forages, oilseeds, or grains present a hazard as feeds or foodstuffs. Our recent increased concern arises from our recognition that a hazard may be present even at very low levels of mold contamination if the mold is a toxin-producing strain of Aspergillus flavus.

In view of this hazard and the occurrence of aflatoxin in moldy peanut meal in England, the first commodity to be examined by the Department of

Agriculture was peanuts. In 1963 the Department made a survey of aflatoxins in peanut stocks held by the Commodity Credit Corporation. This study showed a close relationship between damage in peanuts and the presence of aflatoxin.

The selectivity of contamination in damaged peanuts provides a way for assuring that peanuts are free from aflatoxin. This is by removing broken and shriveled kernels and any that show discoloration. Sorting and selection have been a practice for many years. The finding that molds selectively occur on the damaged kernels makes their removal mandatory from all products.

It was of course necessary to make sure that lots containing damaged peanuts did not enter normal market channels for food or feed. The Department, working with the Department of Health, Education and Welfare, started a four-part program in cooperation with peanut producers, shellers, and processors to assure that only high-quality peanuts are marketed for foods, and that those not meeting these standards are channeled into other uses.

The major points of this program were as follows: (1) changes in the price support program to provide better control for the quality of marketed peanuts; (2) educational assistance to the peanut industry to acquaint them with the best known methods of safe growing, harvesting, drying, storing, shelling, and processing; (3) Federal-State inspection of all lots of shelled peanuts; and (4) a research program seeking ways to eliminate damage due to molds.

Let's examine the fourth phase of the program--research. The major commodities we are investigating in our initial studies are peanuts, cottonseed, cereal grains, and soybeans. In this research, we have four broad objectives: (1) To find practical methods for preventing, or at least minimizing, the growth of mold in agricultural products. We are approaching this objective by determining at what stage in the growth, harvesting, and later handling or storage of a commodity that mold and contamination by toxic substances are most likely to take place. (2) To develop rapid methods for detecting aflatoxin and to solve any special problems in speeding up this detection in each commodity. (3) To discover practical methods of removing or destroying toxins that may contaminate agricultural products. (4) To find more definitely what happens to aflatoxin during metabolic processes in animals.

This research is now being conducted in seven divisions of the Agricultural Research Service, a number of State Agricultural Experiment Stations, and in several foreign countries under the PL480 program. Information from research in England on tolerance to aflatoxin in various animals indicates that ducklings are highly susceptible, rats and mice are resistant, and sheep are apparently nearly immune. In susceptible species, the tolerance increases with age.

Much research centers on oilseeds but this audience is interested in what may be known about the situation for wheat. At the outset we might expect the situation to be better than that for a seed or fruit that comes directly in contact with the soil from the standpoint of mold inoculation. Minimal mold damage is also favored by the fact that wheat rapidly loses moisture on ripening and is generally harvested at moisture levels that are too low to support mold growth. The low humidity which prevails at harvest in much of our wheat-producing areas helps the harvest at low moisture without resort to artificial drying.

As a result of this favorable situation for the wheat harvest in this country, and of the care taken by the grower to harvest it at moisture levels safe for storage, relatively little mold damage occurs. Indeed, in some 82 samples of No. 1 through No. 5 wheat collected according to a statistical design from our principal markets during the past year, and analyzed at our Northern Laboratory, no aflatoxin was detected.

We do know, however, that the Aspergillus flavus molds will grow on wheat and will produce aflatoxin. Such experiments have been carried out in the laboratory. Wheat at high moisture levels has been shown to be a good medium on which to produce aflatoxin. So have the other cereal grains. Quite interesting is the finding that the same Aspergillus flavus molds produce little aflatoxin when grown on soybeans.

With this in mind, we analyzed some 123 samples of sample grade wheat. Since mold damage is one of the factors in determining sample grade we should expect to find aflatoxin in these samples, if anywhere. These, like the other samples, were collected according to a statistically designed sampling plan from carload receipts at the principal markets. Only two of the 123 samples showed analytically detectable amounts of aflatoxin and these were at trace levels. (The analytical method does not unequivocally identify aflatoxin and the presence in these samples has not been confirmed by biological tests.)

These results are reassuring for the safety of our wheat grain both as a food and feed. Nevertheless we cannot become complacent. We are also studying some of the processed seeds to find out what happens to possible contamination. There appears to be no particular problem with oil made from contaminated oilseed. A certain proportion of the aflatoxin present in the seed appears in the oil. The exact amount depends upon the processing conditions, but it appears that most of the aflatoxin present in an oil is removed during refining. The last traces are removed during bleaching. Therefore, since all our edible grade oils are refined and bleached, they do not appear to be a potential source of aflatoxin contamination.

In our utilization research, we have also done some work on the removal or inactivation of aflatoxin in peanut products. We do not yet have a procedure that we can put into practical operation at this time, but several approaches look promising. For example, the acetone-hexane-water mixed solvent, developed to remove gossypol from cottonseed used also removes aflatoxin. The aflatoxin goes into the oil, just as the gossypol does. But, as I have just said, the oil presents no obvious problem at this time.

In these studies...as in so many new fields of research...we have had to look for better methods and techniques to speed the progress of the work. As a case in point, we have developed methods for the analysis that are faster, more accurate, and more sensitive than those available just a year ago. The procedure we used for the peanut survey required an elapsed time of 2-1/2 days to complete. Now the elapsed time is down to about four hours. But even though the new method is a vast improvement, we should increase the sensitivity of our tests even further.

These are only a few examples of the ways in which the U. S. Department of Agriculture is moving against the potential hazards of mycotoxins, through both research and action programs. *We do not consider these hazards particularly dangerous*. *There have been no known injuries to human beings from this source*.

We do know that these toxins can be harmful, or even fatal, to some lower forms of animal life...particularly in the young. Furthermore, we cannot afford to ignore the possibility that some further hazards could develop if nothing were done to prevent their arising.

MICROBIOLOGY OF WHEAT AND FLOUR: REDUCTION OF MICROBIAL POPULATION DURING MILLING

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Work on the microbiology of wheat and flour began at the Northern Division in 1963. The studies were stimulated by the increased use of flours in refrigerated, frozen, and cooked convenience foods, where numbers and kinds of microorganisms in flours are important. The plan included a survey of commercial flours throughout the country to determine the microflora and numbers of microorganisms present and a study of processing methods or process modifications a miller could use to produce finished flours with microbial counts as low as possible.

The survey of commercial flours milled in 1964, conducted by Dr. C. W. Hesseltine and R. R. Graves of the Northern Division's Fermentation Laboratory, showed that bacterial counts in the flours varied from 220 to 8,600 per gram, with the original wheats varying from 15,000 to 660,000 per gram. Mold counts in flours ranged from 90 to 8,100 per gram, with the original wheats varying from 80 to 1,400 per gram. Bacterial counts were much lower in the flour than in the wheat from which it was milled. This condition is normal since most microorganisms are located at the outside of the kernel and in the crease, and should stay with the feed fractions upon milling. For some flours the mold counts, however, were higher than in the wheats. This occurrence shows that some mold growth and pickup of mold by the flour may occur during milling. In general, microbial counts of most of the commercial flours included are quite low, so that wheat flours presently used in convenience foods are probably lower in microbial content than the other ingredients.

Fungi most frequently found in flour by Hesseltine and Graves were *Aspergillus candidus* and a *Penicillium* in the *cyclopium* series. Other species of the genera *Aspergillus* and *Penicillium*, *A. flavus*, *P. urticae*, and *P. citrinium* were also prevalent. No aflatoxin was detected in the culture filtrates from 18 strains of *A. flavus* isolated from flour.

Bacteria isolated from wheat and flour were principally gram-negative, with organisms belonging or closely related to the genera Flavobacterium and Paracolobactrum predominating. No salmonellae or coagulase-positive staphylococci were detected. Other microorganisms of concern from the standpoint of public health and sanitation were not detected in flour, or were present in relatively low numbers.

The principal factors influencing the microbial population of milled flour are: (1) condition of incoming wheat; (2) wheat cleaning treatments or other treatments applied before milling; (3) sanitizing agents used before milling; (4) condition of milling equipment; (5) combination of flour streams to give the desired products; (6) treatments of flour after milling, such as bleaching and maturing; and (7) conditions of storage imposed on flour before its use.

Studies carried out with a Buhler experimental flour mill to determine the microbial populations of flour streams showed that counts tended to follow the ash contents, being lowest in the purest endosperm flours and highest in the most impure flours. Microbial counts in feed fractions were much higher than in flour fractions. Thus, shorts had the same counts as the original wheat or higher, while bran had counts up to three times those of the wheat. These results demonstrate how mill streams must be especially selected if flour of low microbial count is to be produced. Fortunately, commercial patent flours ordinarily exclude streams of high contamination.

Studies have also been carried out to learn the effects on the final flour of ordinary washing and dry scouring of wheat; of adding chlorine, chlorine dioxide, or bromine to wash and temper waters; and of washing wheat with limewater or hydrogen peroxide. The more effective treatments included washing with limewater, tempering with dilute acetic acid solution containing chlorine, washing and tempering with hydrogen peroxide solutions, and dry scouring before tempering. Sanitizing agents such as chlorine, bromine, and chlorine dioxide in the temper and wash waters were helpful in reducing microbial counts, which usually decreased further with higher levels of the agents or with an increase in the number of applications. As shown in Table 1, not one of these methods by itself, however, would be suitable for reducing the microbial count of flour from wheat of high microbial population to below 5,000 per gram as required in some convenience foods. Moreover, the efficacy of treatments seemed to vary with blends of wheats, undoubtedly because of differences in their microbial floras, storage history, and inherent kernel characteristics.

Recent studies on storage of flour at moderate temperatures, in the range of 100° to 140°F., have shown that microbial count can be reduced to low levels with little flour damage. With a flour of high microbial population (100,000 bacteria per gram) it was possible to reduce the count to 5,000 per gram by storing the flour for about 105 days at 82°F., 24 days at 99°F., 7 days at 115°F., less than 1-1/2 days at 125°F., or less than 1 day at 135°F. Reduction to below 500 per gram was obtained by storage for an equal additional time at a given temperature. The rate of destruction of the microorganisms displayed an Arrhenius dependence upon temperature.

Table 1.--Microbial counts in flours (wheat basis) after treatments of 1964 Illinois HRW wheat blend before milling

Treatment	Bacterial counts		Mold and yeast counts
	50% extraction flour	70% extraction flour	70% extraction flour
	count/g.	count/g.	count/g.
Control	65,000	100,000	430
Double temper with chlorine water (300 ppm)	46,000	78,000	270
Double temper with 0.6N acetic acid solution (pH 2.5) containing chlorine (300 ppm)	26,000	48,000	10
Dry wheat to 10% moisture, double temper with chlorine water (300 ppm)	44,000	89,000	165
Double temper with bromine water (300 ppm)	42,000	68,000	245
Wash with limewater, 2nd temper with chlorine water (300 ppm)	17,000	23,000	35
Commercial wheat washer, 1 pass	69,000	75,000	310
Commercial wheat washer, 2 passes	48,000	63,000	90
H_2O_2 in wash and temper waters	32,000	44,000	225
Scour after 1st temper	47,000	71,000	165
Scour before and after 1st temper	48,000	68,000	30
Strip in rice huller before tempering	48,000	73,000	90
ClO_2 in 2nd temper (190 ppm)	71,000	105,000	540
ClO_2 in 2nd temper (1900 ppm)	34,000	66,000	140
Cl_2 in 1st temper (300 ppm) ClO_2 in 2nd temper (170 ppm)	58,000	81,000	290
Cl_2 in 1st temper (300 ppm) ClO_2 in 2nd temper (1700 ppm)	48,000	88,000	135

Flour stored at 100°F. or less suffered no apparent gluten damage as shown by Farinograph and gluten-separation tests. At temperatures of 100° to 125°F. gluten damage appeared to be negligible if warm storage was discontinued after attainment of 99 percent kill. Above 125°F. gluten damage was small but noticeable, even when heating was discontinued immediately upon reaching 99 percent kill. No starch damage was indicated by amylograph tests with any of these flours. With storage at higher temperatures, paste viscosity was actually increased, probably because enzymes were destroyed during storage.

Warm storage appears to be feasible for processing flours to reduce their microbial populations to less than 5,000 per gram. It has advantages over more severe treatments in that no chemicals are used, no food regulations are involved, and flour damage can be avoided or held to low levels. Also, only that portion of the mill's output that must adhere to rigid microbiological specifications need be treated.

Another method is fumigation of the wheat with ethylene or propylene oxide before milling. Straight flours with total microbial counts less than

500 per gram were produced from wheats treated with either epoxide. Propylene oxide was not as effective as ethylene oxide, and longer treatment, higher temperature, or higher concentration of the epoxide was required to achieve the same degree of kill. Conditions for producing flours with total microbial counts below 500 per gram were: with ethylene oxide, treatment of wheat at 13 percent moisture content for 1-1/2 hours at 120°F. with an epoxide concentration in the vapor space of 0.5 gram per liter; with propylene oxide, treatment of wheat at 13 percent moisture for 6 hours at 120°F. with an epoxide concentration in the vapor space of 1.5 grams per liter. Microbial counts of feed fractions were reduced to very low values also. Molds were almost completely destroyed in all fractions.

Treatment of wheat was preferable to flour treatment, since extensive gluten damage was incurred when flour was treated with ethylene oxide, whereas damage was negligible when wheat was treated with this epoxide before milling. Some damage was also noted when flour was treated with propylene oxide, but none when wheat was treated. Amylograph tests with the various flours clearly showed that when flour was treated there was considerable reaction between the epoxides and the flour, whereas when wheat was treated, reaction was negligible. Chemical residues of epoxide and the corresponding glycol were greater with propylene oxide than with ethylene oxide, and increased with higher temperatures, higher epoxide concentrations, and longer treatment times. Treatment of wheat at higher moistures was more effective but resulted in excessive residues of glycol in the flour ultimately milled from the treated wheat.

Our work therefore shows that use of these fumigants on flours presents problems in flour damage and chemical residues. When the wheat is treated, the residues are much lower, and flour damage is minimized, since the outer part of the kernel protects the endosperm.

Heating wheat before milling is still another process that we have studied. This process is relatively simple, and, since wheat is always stored at the mill, it might be preferred by some millers over warm storage of flour. Table 2 shows results obtained when portions of wheat having high microbial population were heated to various temperatures and held for varying lengths of time. The wheats were then cooled to 75°F. and tempered with water containing 300 ppm chlorine before milling. Treatment of the wheat at about 140°F. for 6 hours at 13 percent moisture, in combination with the use of chlorine in the temper waters, was effective in yielding undamaged flour with less than 1 percent of the microbial count of flour from untreated wheat. Treatment at higher moistures is even more effective, but gluten damage then becomes apparent. Starch was not damaged by these heat treatments.

Summary. Our studies have shown that it is possible to control the microbial population of products milled from wheat by relatively simple treatments. Products with total microbial counts well below 5,000 per gram for use in convenience foods can be obtained from most wheats by proper combinations of wheat treatment, mill cleaning, flour stream selection, and flour treatment. In milling, up to 95 percent of the microbial population of a wheat is removed with the feed fractions, so that the microbial count of the flour will be much lower than that of the original wheat unless microorganisms are picked up from the mill itself.

Table 2.--Heat treatment of 1964 Illinois HRW wheat before milling

Wheat treatment conditions			Flour	
Temp. °F.	Time	H_2O %	Microbial count/g.	Flour damage
Control wheat			80,000	Control
126	24 hr.	13.0	3,200	Negligible
142	24 hr.	13.0	220	Slight
147	24 hr.	13.0	<100	Appreciable
138	4 hr.	13.3	9,600	None
140	6 hr.	13.0	500	Negligible
149	4 hr.	13.2	<100	Slight
140	4 hr.	10.4	13,000	Negligible
140	4 hr.	13.0	6,700	Negligible
140	4 hr.	14.8	500	Appreciable
171	30 min.	13.0	<100	Extensive
181	15 min.	13.2	200	Extensive
186	10 min.	13.0	400	Extensive
190	5 min.	13.0	150	Extensive

Thorough cleaning and use of sanitizing agents in washing and tempering wheat help to produce flour of reduced microbial population, but these treatments by themselves are not satisfactory for wheats with high microbial populations. Sanitizing agents also prevent contamination of wheats by microorganisms in the raw, untreated water used in washing or tempering, reduce odors and slimes in the washing and tempering equipment, and reduce or prevent the accumulation of moldy deposits in the early stages of the mill break system.

Treatment of wheat with epoxide fumigants results in subsequent production of flour and feeds with very low microbial populations. Very little flour damage results, but, as with fumigants in general, some chemical residues are left in the flour.

Storage of flour at temperatures of 100° to 140°F. appears to be a satisfactory way of removing 99 percent or more of the microbial population without causing objectionable flour damage. Heating wheat before milling appears to be even more satisfactory and should be adaptable to practically any commercial mill.

REDUCTION OF THE MICROBIOLOGICAL POPULATION OF FLOUR

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Under contract with the U. S. Department of Agriculture the American Institute of Baking has made a study to find practical, relatively inexpensive means for greatly reducing the number of microorganisms in wheat flour. This research was conducted by Dr. Lazare Wiseblatt and Richard Makowski of the Institute staff.

Flour free from microorganisms is not required in the production of the conventional bakery foods. In these products baking destroys most of the organisms. Flour with a low microbial population is highly desirable in the production of foods such as meat pies, soups, and biscuits intended for frozen or refrigerated storage. In such products microorganisms can multiply rapidly if storage conditions are poor, resulting in spoilage or the possibility of food poisoning.

To determine the effect of microorganisms of flour on the quality of certain frozen and refrigerated foods during storage and to test the effectiveness of sterilizing treatments, flours were inoculated with approximately one million per gram of each of four microorganisms representing types to be expected in flour. *Bacillus subtilis* was used as a spore-forming, heat-resisting spoilage organism, *Aspergillus flavus* as a typical mold, *Staphylococcus aureus* as a food poisoning type, and *Escherichia coli* as representative of fecal contamination.

In the study of effect of microorganisms on stability of typical frozen and refrigerated foods pie dough, soup thickened with both flour and cracker meal, and biscuit dough were prepared from inoculated and uninoculated flours of types used commercially. Pie dough and soup were stored at 20° and -3°F. The higher temperature is unsatisfactory for storage but is one the products may reach under adverse conditions. The biscuit dough was canned in standard containers used commercially for refrigerated biscuits. It was stored at 37°F., representing good storage, and at 37°F. cycled once a day to 70°F. for six hours to represent unsatisfactory storage.

At regular intervals samples were examined for microbial count and tested for evidences of deterioration. Pie dough became rancid. Soup thickened with inoculated flour or cracker meal underwent a drastic change in consistency, while that with uninoculated thickeners browned excessively. Refrigerated biscuits lost volume when baked, the crumb became gummy and gray, and an off-odor developed. The number of days in storage before these changes developed is given in Table 1. This shows that deterioration of the frozen pie dough and soup was accelerated by both higher storage temperature and high microbiological count. Performance of the refrigerated biscuits did not vary between inoculated and uninoculated samples but was greatly affected by temperature.

In the frozen pie dough from uninoculated flour there was no significant change in total numbers of microorganisms or in numbers of the four test organisms at either storage temperature. In pie dough from inoculated flour the count of *B. subtilis* increased slowly at 20°F. though there was no change at -3°F. Count of *S. aureus* did not change at either temperature, while *A. flavus* count decreased at both temperatures and this organism soon disappeared entirely. *E. coli* proved to be readily destroyed and when inoculated into flour did not survive until the various products were made from the flour.

Soup was thickened by addition of flour followed by heating to 195°F. and immediate cooling. This heating process greatly reduced the number of microorganisms. With uninoculated flour few microorganisms remained. Of the four test organisms only *B. subtilis* was found consistently and the numbers did not increase during storage. In soup from inoculated flour *A. flavus* disappeared entirely, but appreciable numbers of *B. subtilis* and small numbers of *S. aureus* survived. These increased greatly during the freezing and defrosting process.

Table 1.--Number of days product was stable

	Uninoculated flour		Inoculated flour	
Storage temperature	20°F.	-3°F.	20°F.	-3°F.
Pie dough	42	134	43	84
Soup with flour	231	246	36	120
Soup with cracker meal	235	250	103	145
Storage temperature	37°F.	37°-70°F.	37°F.	37°-70°F.
Biscuit dough	56	28	56	28

Microorganisms naturally present in the refrigerated biscuit dough made with uninoculated flour underwent no significant changes in numbers at 37°F. but increased when the temperature was cycled from 37°F. to 70°F. In the dough made with inoculated flour the total number of organisms and counts of *B. subtilis* and *S. aureus* decreased markedly at 37°F. When the biscuit doughs were cycled the counts of *B. subtilis* and *S. aureus* did not change. The count of *A. flavus* decreased greatly under both storage conditions.

Several bactericidal agents suitable for use in foods were tested with inoculated flours. Only propylene oxide proved to be effective against the spores of *B. subtilis*. A concentration of 1.4 percent propylene oxide based on the weight of flour acting for 16 hours at 21°C. (70°F.) reduced *B. subtilis* from more than a million to 9,000 per gram and completely destroyed the other organisms. It was more effective at the usual flour moisture of 12 to 14 percent than at higher moistures. Results of a typical experiment on the effect of propylene oxide level and temperature are given in Table 2. This shows that a moderate increase in temperature of treatment greatly increased the effectiveness of the agent. At all effective concentrations the flour after treatment had a distinctive, undesirable odor which could be eliminated by heat. After the heat treatment the flour was completely sterile.

This suggested that greatly reduced concentrations of propylene oxide acting for a shorter time might be effective if followed by a heat treatment. Results of such an experiment on *B. subtilis* spores are given in Table 3. Time of treatment with propylene oxide was reduced to four hours at 36°C. (97°F.) after which the flour, one-fourth inch deep in trays, was heated at 130°C. (266°F.). Reduction of *B. subtilis* from the initial inoculum of 450,000 per gram by propylene oxide alone is shown in column 2 where the data, as in the entire table, are in thousands per gram. The effectiveness of heat is well demonstrated. For example, 25 ppm of propylene oxide followed by heating for 20 minutes was as effective as 1,000 ppm without heat. The comparative ease of destruction of *S. aureus* by the same treatments is shown in Table 4 and *A. flavus* in Table 5. No table is given for *E. coli* since these organisms were readily destroyed by low levels of propylene oxide without heat.

The effect of heat was so pronounced that experiments were conducted using only the heat treatment of the flour. Data in Table 6 on reduction of *B. subtilis* spores after treatments at various times and temperatures showed that this procedure was very promising. The only visible evidence of a harmful effect on the flour was discoloration after the treatments below and to the right of the heavy line. Other experiments showed that a 45-minute treatment of layers of flour one-fourth inch deep in an oven at 130°C. (266°F.) achieved a high degree of destruction of the test organisms. Typical data are given in Table 7.

Table 2.--Propylene oxide vs. *B. subtilis* survival in flour

Temperature °C.	Propylene oxide as % of flour--18-hour exposure 0	0.3%	0.6%	1.2%	2.4%
21 (70°F.)	53,000	6,300	3,300	4,100	600
35 (95°F.)	48,000	1,800	600	200	0

Table 3.--Propylene oxide and heat vs. *B. subtilis* in flour--propylene oxide treatment: 4 hr. at 36°C. (97°F.)--*B. subtilis* spores 450,000 per gram flour

Propylene oxide, ppm on flour	Heating time, minutes at 130°C. (266°F.) 0	10	20	30	45	60
			B. subtilis, thousands per gram			
25	380	176	24	1.6	0.2	0
50	315	51	3.9	0.6	0	0
100	250	10.9	1	0.2	0	0
200	108	4.1	0.7	0.1	-	0
500	66	0.9	0.2	0	-	-
1000	33	0.2	0	-	-	-

Table 4.--Propylene oxide and heat vs. *S. aureus* in flour--propylene oxide treatment: 4 hr. at 36°C. (97°F.)--*S. aureus* inoculum 860,000 per gram flour

Propylene oxide, ppm on flour	Heating time, minutes at 130°C. (266°F.) 0	10	20	30	45
		S. aureus, thousands per gram			
25	102	18.9	2.1	0.1	0
50	49	3.8	0.4	0	0
100	16.7	1.7	0	0	0
200	2.7	0.6	0	0	-
500	0.8	0.1	0	0	-
1000	0.3	0	0	-	-

Table 5.--Propylene oxide and heat vs. *A. flavus* in flour--propylene oxide treatment: 4 hr. at 36°C. (97°F.)--*A. flavus* inoculum 700,000 per gram flour

Propylene oxide, ppm on flour	Heating time, minutes at 130°C. (266°F.) 0	10	20	30	45
		A. flavus, thousands per gram			
25	31	6.6	0.4	0	0
50	7.8	1.2	0	0	0
100	2.1	0.5	0	0	0
200	1.4	0.2	0	0	0
500	0.3	0	0	0	-
1000	0	0	0	0	-

Table 6.--Heat vs. *B. subtilis* in flour--*B. subtilis* spores 540,000 per gram--heating time--(minutes)

Temperature °C.	5	15	30	60	120	360
		B. subtilis spores, thousands per gram				
90	-	-	-	-	92	3.5
110	-	-	-	2.4	1.1	-
130	-	-	1.7	0.5	0.1	-
150	-	-	0.7	-	-	-
170	42	2.8	-	-	-	-

Table 7.--Heat vs. microorganisms in flour--treatment: one-fourth inch deep layer of flour, heated 45 minutes in oven at 130°C. (266°F.)

Organism	Inoculum, thousands	Count after treatment, thousands
B. subtilis	2,400	2.4
" "	14.3	0
S. aureus	1,390	0.25
" "	860	0
A. flavus	710	0
" "	450	0
E. coli	300	0

Flour treated in this manner appeared not to have suffered permanent damage of its functional properties. Pastry flour with and without the heat treatment was made into pie dough and the baked crusts were indistinguishable. For flour intended as a thickening agent this heat treatment improved thickening power by inactivating amylases. The thickening power of cracker meal was unaltered.

Flour to be used for yeast-leavened foods would be expected to suffer most from heat treatment. However, when diastatic malt was added to restore a satisfactory level of amylase activity as determined by the amylograph, and absorption was increased by about 8 percent to compensate for moisture lost during the treatment, excellent bread was made by both sponge and dough and straight dough methods. Rather surprisingly it was found necessary to add diastatic malt to the optimum level to obtain good baking powder biscuits. When this was done the biscuits were as good as those from the untreated flour.

The heat treatment which has been described need not be conducted as a batch process. With a relatively low capital investment it could be adapted to a continuous process. If a thermal efficiency of about 40 percent is assumed for the process, the heat requirement would be about 50,000 BTU per 100 pounds of flour. At the industrial rate for gas fuel in the Chicago area, the fuel cost would approximate 4.5 cents per 100 pounds of flour.

Heat alone proved to be nearly as effective as propylene oxide at levels of 100 ppm or below. Because of the flammability of propylene oxide more elaborate equipment might be required. If propylene oxide is used at levels of more than 1,000 ppm, which appears to be necessary for sterilization of flour, the removal of the odorous residue becomes essential. Thus it appears that heat treatment alone has advantages over other means of reducing the microbiological populations of flour.

THE FREIGHT CAR SHORTAGE

Abe McGregor Goff
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It is always pleasant to return to Boise, to Idaho, and to the Pacific Northwest. There is nothing quite like getting back to your home country. I feel more a host than a visitor, so add my personal welcome to that already extended to you who come from outside the State. You have honored us by your presence. This conference also gives me the opportunity to discuss a problem that concerns you, as well as those of us in the field of transport regulation.

As a boy, I grew up with wheat in the Palouse country of eastern Washington and northern Idaho, adjacent to Idaho's mountains. I shocked bundles behind a binder on my father's farm. In high school and college, at harvest time, I pitched bundles to load the wagons that fed the steam-powered thresher, that went from farm to farm. I served my time, as did the rest of the transient crew, sleeping at the day's end in my bedroll at the strawstack. We started the day early and worked late. The high spots of each day came when we sat on the planks at the counters on each side of the cook-wagon and downed those tasty, hearty meals prepared by farm-wife cooks. I worked also as a loader with a header crew, standing behind the driver of the sloping header boxes, directing with a pitch-fork the flow of the heads of wheat from the header spout. I also drove a wagon hauling sacked wheat to the warehouse, loading and unloading my own wagon. I even worked in warehouses carrying and lifting the 110 to 135 pound sacks to fill the warehouse. Further, I loaded out boxcars in the days of sweat and a strong back, before the advent of labor-saving machinery. Those days are long gone now for me, as well as for the modern farmer.

The Interstate Commerce Commission, of which I am a member, has the task of regulating all modes of interstate surface transportation. It is by far the oldest and the largest of the Federal regulatory commissions. Impelled primarily by agricultural rate abuses in the Midwest, the Congress in 1887 enacted the Act to regulate interstate commerce and vested the ICC with authority to regulate the carriage of passengers and goods from one state to another by railroad. Today the Commission, due to change in circumstances, a growing population, and development of new modes of transportation, regulates not only railroads but all the other modes of surface transportation for hire--rail, bus, and truck lines, sundry water carries on rivers and canals, domestic coastwise shipping, pipelines, freight forwarders, express companies, brokers of transportation, and other fringe transportation enterprises. All of these are subject to what we call economic regulation except where certain exceptions apply. In addition, we exercise jurisdiction over the safety of interstate train, truck, bus, and pipeline, as well as other thousands of otherwise exempt interstate private motor carriers who do not haul for hire. While there is considerable carriage of wheat and flour by barge and truck, shipment by rail far transcends carriage by these other two modes, in the major wheat-producing and warehousing areas of the country. The coming of the railroads opened up and settled the great wheat regions west of the Mississippi by providing access to markets.

I take it that the major objective of your conference is to promote greater utilization of wheat and its products. Obviously, wheat cannot be marketed or utilized unless promptly and efficiently transported to the processor and user. In any event, it must be moved in time to free local storage facilities for new crops and before loss by spoilage through exposure to the elements.

You know that for at least the past 15 years wheat growers and producers have suffered from progressively severe shortages of freight cars with critical shortages during and following the harvest season. Primary factors are an inadequate car ownership, a relatively high percentage of unserviceable cars, and the faulty utilization of existing equipment.

The Commission has repeatedly pointed out to the Congress that the national car supply has dwindled to a new low for this century, despite efforts of carriers to repair and rebuild cars, because purchases are confined principally to equipment of a specialized nature. For example, the tri-level flat car which is now a common sight on the nation's railroads has enabled the railroad industry to recapture previously lost automobile traffic. Large quantities of this and other specialized type cars have been added to the national car supply, but they have little or no significance to many other shippers--of grain, for instance.

The railroads just don't own enough ordinary boxcars, and generally show little inclination to acquire them. Plain boxcars are the work force during harvesting periods. The supply has been dwindling for ten years and with the shortage, coupled with our expanding economy, we need many more, and not less, of this type of car. Viewed also from the national defense standpoint, the car shortage becomes a matter of vital concern.

Survey of the situation discloses that since 1947 the railroads' total car fleet has been reduced by over a quarter of a million cars. Of course there has been some increase in the average capacity of new cars built. But this increase in capacity has not offset the loss from the reduction in the number of cars. As stated in our Chairman's testimony before the House Interstate and Foreign Commerce Committee last month: "Between January 1956 and January 1965, the number of freight cars declined from 1,774,614 to 1,550,447 a decrease of over 200,000 cars. As a result, critical shortages of varying duration and severity have occurred in every producing area of the country. This is not a regional or sectional problem."

Freight car shortages of considerable proportions have occurred this fall in all areas of the country. Shortages are more severe than at the same time last year with the principal deficit in the boxcar area. The reported average daily shortage of boxcars for the week ended October 23, 1965, was over 8,500. We can well shudder at the thought of what the situation can be ten years from now, if shortages continue to worsen as they have in recent years.

Further complicating matters this year was the fact that all of our grain crops exceeded last year's production. As you know, snow, rain, and floods in the Midwest and Northwest damaged some crops but principally delayed harvesting operations. Now there is a real clamor for service. In past years the situation has been aggravated by volume movements of old grain just at the wrong time from a car shortage standpoint, under the Commodity Credit Corporation's relocation and export orders. We believe we have now worked out alleviation with that agency by shifting time of movement to less critical periods.

To expedite handling of cars the Commission last year tried stepped-up demurrage charges. This helped by forcing prompt unloading and unloading while cars were in the hands of shippers or receivers of freight. But the most serious delay is use on lines of the non-owner carrier with this detention preventing the owning road from supplying cars to its shippers.

The Association of American Railroads publishes car service rules by agreement of a majority of its members, which are designed to speed the flow of empty boxcars to carriers serving critically deficit areas. These AAR rules are, of course, voluntary and carry no penalty. They are not agreed to by several carriers who do not comply and who insist that the per diem rental for use is too high. These rules, however, provide a point of departure and our Safety and Service agents in the field have been watching compliance closely. At times there has been serious non-compliance. Where there has been such a breakdown in compliance, the Commission has immediately issued its own orders to direct the return of cars to areas which are not receiving an equitable share of the supply.

Such orders require prompt handling of cars by carriers, prescribe weekly return of empty cars to owning lines in the absence of proper loading, restrict loading of certain classes of cars to specified areas, and prohibit circuitous routing of traffic. Where a car shortage is local and not too severe, the Commission's orders provide reasonably satisfactory relief. However, they do not solve the problem of shortages in total supply. The scant supply is like a short blanket. Pulled up by our service orders to cover the shoulders, there is immediate complaint that the feet are cold.

An order requiring cars of a specified kind to be returned promptly to owning roads or in the direction of owning roads may have an adverse effect on some shippers in certain areas, but it will have some wholesome effect in improved distribution and car service. In response to shipper pleas from western sections for assistance in securing boxcars, four car distribution orders were issued this season directing certain railroads to deliver a weekly total of 1,225 empty plain serviceable boxcars to specified midwestern and western railroads to relieve shortages.

The orders prohibit any railroads from intercepting and using empty boxcars. Compliance with the orders is vigorously policed by our field force. Busy, busy, busy is the lot of the car service agent in the field and at headquarters. They run down complaints, receive and apply constant pressure, work long hours, but keep on top of a bad situation to a degree I find admirable. The orders are proving materially effective in adjusting inequities in the distribution and supply of boxcar equipment. The best we can do, however, is aimed at making "all suffer equally" if that is any consolation to you who are hurting from lack of equipment. Remember this simple fact. There are not enough cars to go around.

All this points to an intolerable situation. Cars tend to collect in hands of railroads serving the populous east where carriers deliver more freight than they have loads to ship back. Lines that ship out more freight than they terminate face a continuing shortage. The originating railway must send its car on its way to pass into other hands. Except for our emergency car orders, any railroad can hold and use a foreign car that comes into its hands as long as it cares to and is charged only the AAR schedule of per diem rental. Under this schedule it is cheaper to rent than to build or buy and own.

There is no mystery about the cause of the decline in the nation's freight car supply. It is simply much easier for a railroad to rent a car from another railroad than it is to own one. The per diem scale of the carriers, whereby car owners are reimbursed for the use of their equipment by other carriers, is too low to reflect the full value of such cars to their owners. The current per diem charges range from $2.16 to $12.18, depending upon the value of the car. Some railroads not parties to the AAR agreement refuse to be liable for, much less pay, at even these rates. The charges do not cover the full current costs and risks of ownership, not to mention profit, and are considerably below the amount which the car owner could earn daily by use of the car on its own railroad. The present voluntary scale has the effect of discouraging construction and in some respects places a premium upon inadequate car ownership. That much new car equipment is specialized for single types of shippers further complicates the situation.

In the session of Congress just adjourned more headway was made than before on this problem. For many years bills were introduced to relieve the malady but met the solid opposition of Congressional delegations east of the Mississippi. This year the Senate passed S. 1098, with some amendment. This bill was introduced by Senator Magnuson for himself and 32 other senators. It would implement Legislative Recommendation No. 6 in our Commission's 78th Annual Report. On the House side, committee hearings were held right at the end of the session and the Senate bill was reported out with few changes, but too late for action on the floor.

Under the bill a practical incentive can be offered to the railroads to build or acquire more freight cars. The purpose is to grant the Interstate Commerce Commission authority to prescribe per diem charges for use of railroad freight cars on a basis that will encourage railroads having a deficit in car ownership to acquire and maintain their proportionate share of freight cars. It should make it more profitable to own cars than to rent them.

The Commission at one time attempted to encourage car ownership by the imposition of a penalty per diem charge which, it was believed, would cause car-deficient railroads to increase their ownership. In the so-called Palmer case, a three-judge court set aside the Commission's order on the ground that the Commission could not prescribe per diem charges for "regulatory purposes" (Palmer vs. United States, 75 F. Supp. 63). There is thus sufficient doubt about our regulatory authority that it should be made clear by specific legislation that the Commission has authority to establish per diem charges at a level or levels that would make ownership of equipment more attractive. S. 1098, thus, proposes that the present law be amended by adding specific authority for the Commission to: "* * * provide full and reasonable compensation to freight car owners, contribute to sound car service practices, and encourage the acquisition and maintenance of a car supply adequate to meet the needs of commerce and the national defense."

The Bill is incentive in character. The Commission would be empowered to add a deliberately higher "incentive" rate to apply to classes of cars found in short supply, with leeway to excuse payment of the "incentive" rate under special circumstances. The Commission testimony favors the bill. Every wheat shipper who suffers from car shortages should give it solid support. At any rate, I urge that now is the time for grain interests and other shippers to join forces. The legislation is backed by the Departments of Agriculture, Commerce, Defense, the General Services Administration, and the Comptroller General. It is supported by the National Association of State Railroad and Utilities Commissioners. Also behind the measure are the American Farm Bureau Federation, the National Council of Farmer Cooperatives, many other shippers and shipping associations, in the grain, milling and lumber trades, and a sizable group of railroads, particularly from our western states. Enactment of the bill will not provide a miraculous cure-all but it will certainly be a step in the right direction. Never before has positive legislation come so close and the time for action is now.

If the proposed legislation is enacted, the Commission's first step would be to determine the extent to which particular railroads are deficient in car ownership. Some of the information required for this purpose would be obtained from the record in Ex Parte No. 241. This investigation was instituted by the Commission in December 1963, because of the rapidly dwindling supply of railroad freight cars and the realization that the Commission's enforcement powers were not adequate to cope with the crisis which gets worse from year to year. Our purpose in undertaking the investigation was to ascertain the level of ownership adequate to meet routine, as well as emergency, shipping requirements in all areas of the country. An interim report confirmed what we largely knew before. We need a lot more information that is difficult to obtain from individual carriers. My friends, railroad managerial discretion has not been able to solve the existing problem. The Commission's exercise of its emergency powers and issuance of service orders to alleviate short car supply conditions do not add cars. We are now convinced, therefore, that a different and more comprehensive approach to the ownership and control of freight car supply is necessary. We look to the prescription of car service rules of our own with enforcement teeth in them in place of the voluntary rules of the AAR. When and if authorized by the Act, we expect as soon as reasonably possible to propose a schedule of daily rental charges consistent with the law.

There are now some brighter spots on the horizon. You may have heard of the recent proposal by one western railroad whereby the demand for wide-door boxcars and larger freight cars might be in part met through offering shippers a rate incentive to use the more plentiful narrow-door cars. The proposed rate reductions apparently amount to the carrier's absorbing the added costs of loading and unloading the narrow-door cars. Action by the Congress to alleviate the situation is expected to stimulate other rail carriers, including even the chronic car-short roads, to greater efforts to work out methods of their own to remedy their problem before the Commission steps in under powers to be granted under the proposed legislation.

Also heartening is information recently made public by one of the large car builders that new and larger covered hoppers will soon be produced. According to the Railway Age of October 18, 1965, orders for some 600 of these large-hopper cars are already in and more are anticipated. The new equipment will range up to 6,300 cubic foot capacity. Certainly, as the availability of this equipment becomes felt, the lot of the grain shipper will improve. Further, I was pleased to note that not all carriers are concentrating on specialized equipment in their new car purchases. Railway Age of October 18 reports that the Great Northern and the Missouri Pacific have each ordered large quantities of new cars with emphasis on boxcars and hopper-type equipment.

THE IMPACT OF NEW LEGISLATION ON WHEAT USAGE

Wayne B. Allen
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One fact that cannot be escaped in today's economy is that wheat usage, as well as farm income, is infinitely linked to legislation. The new farm law allows for and may promote an expansion of wheat usage for animal feeds; it will likely not change domestic food usage; it will greatly restrict the potential usage for nonfood products; and it will likely encourage expanded wheat exports. I will go into detail on each of these four uses as they relate to legislation and legislative pricing.

But first, with these thoughts in mind I would like to consider briefly the new omnibus farm bill passed by Congress, titled "The Food and Agriculture Act of 1965", as it relates to wheat, noting the changes over present legislation. There are 8 titles in the law dealing with dairy, wool, feed grain, cotton, wheat, crop land diversion, miscellaneous, and rice respectively. Title V deals with wheat. This is 4-year legislation as compared to a precedent of 2-year legislation in prior years. This will afford increased stability in production, planning, marketing, and financing for the farmer and the industry.

Each farm's share of the wheat produced for domestic food use will be supported at 100 percent of parity, or as nearly so as is practicable. For 1966 the support will be at 100 percent of parity and parity will be set at the close of the marketing year, July 1966. Parity will probably be about $2.57. Commodity Credit Corporation will pay the support on the domestic food-use wheat above $2.00 per bushel. The domestic wheat processors will pay the difference between the national average price-support loan rate, which will be $1.25 per bushel for 1966, and the $2.00 per bushel. For 1966 processors of wheat for domestic use will pay 75 cents for each bushel processed for food uses, the same as this year.

Noncertificate wheat and wheat for export will be supported at the Secretary of Agriculture's discretion at a level based on world market price and the feeding value of wheat in relation to feed grains. For 1966 wheat not accompanied by certificates will be not less than $1.25 per bushel national average, the same as in 1965.

Authority for export certificates is continued, but as a variable export certificate. If the world price is above the domestic price, exporters will be required to buy an export certificate equal in value to the difference, or if the world price is below the domestic price he will be paid a subsidy equal to the difference. If the certificates purchased by the exporters exceed the subsidies paid, at the end of the marketing year the accumulated funds are to be prorated to the producers. Since subsidy payments, October 28th, are 22 cents per bushel on hard winter wheat, it is doubtful that any funds will accrue to producers in 1966. Variable export certificates provide more program flexibility, enable our wheat to be more competitive in world markets with a lower or no subsidy and assure farmers they will get at least world prices for their wheat.

The minimum number of certificates on domestic food use will be 500 million. There was no minimum in 1965. Diversion payments are authorized on additional voluntary diversion acres up to 50 percent of the farm allotment or sufficient acreage to bring the acreage up to 25 acres, whichever is larger. In 1965 the maximum was 20 percent of the allotment or 15 acres. The payment rate could be up to 50 percent of the county loan rate times the farm projected yield. This could be used to get more acres out of production than in past years. Authority is included to exempt flour 2nd clears not used for human consumption from marketing certificate requirements.

A new cropland diversion program under Title VI of the bill will be aimed to retire approximately an additional 2 million allotted acres of wheat each year for 4 years. These acres would be retired on long-term contracts from 5 to 10 years. This cropland diversion program, together with the additional diversion under the new program, could have a significant effect on wheat supplies and consequent cash wheat prices.

Now let's enlarge on how the new farm law allows for and may promote an expansion of wheat usage for animal feeds. The demand for grains for animal feed is rapidly increasing, not only in America but throughout the industrialized world. The fact that industries are booming in much of Europe, Japan, and North America is resulting in more demand for livestock products and hence more feed grains. Last year the United States exported over one-half the world total of feed grains. It was 92 percent cash business, amounting to $880 million dollars. Wheat has been fed extensively in Japan and Europe to livestock and feed wheat as such is widely recognized in the world markets. Wheat usage for livestock feed in the United States has also increased tremendously. Of course, price is the key to expanded feed use in both world and US markets. I pointed out that under the new law as under the 1964-65 law, the Secretary would continue to support all noncertificate wheat at a level based on world market and the feeding value of wheat in relation to feed grains and that for 1966 this would be at $1.25 per bushel national average.

Here are the price relationships that promote wheat as a feed grain, taking into consideration the fact that there are 60 pounds of wheat per bushel and 56 pounds of corn and assuming that pound for pound they are of equal value when substituted as a livestock feed.

DOLLAR VALUE OF WHEAT AS A SUBSTITUTE FOR CORN
(Assuming equal feed value per pound)

When a bushel of corn sells for	$1.12	1.18	1.23	1.34	1.40
Wheat is worth per bushel	$1.20	1.26	1.32	1.38	1.44

However, the summary of an extensive three-year livestock feeding experiment performed by the University of Nebraska College of Agriculture at North Platte indicated that in four comparisons in which cold-rolled wheat was used to replace one half the corn, one ton of wheat replaced 1.13, 1.13, 1.05, and 1.27 tons of corn and in addition the use of wheat resulted in some saving of soybean oil meal and roughage. These figures are supported by the action of local cattle feeders and feed mills in our area who are continuing to use wheat extensively in their rations even though the cost on a pound-for-pound basis exceeds that of corn by 15 percent. The latest market figures (October 28, 1965) gives these relationships:

Kansas City	-	Wheat 1.62	Omaha	-	Wheat 1.59
		Corn 1.21			Corn 1.18

You can see that price relationships at these markets make wheat too high-priced for livestock feed. At Denver, October 21, however, corn was worth $1.28 and ordinary wheat was selling for $1.30, making a favorable wheat-for-feed price relationships. Almost all eastern Colorado, western Nebraska, and Kansas points were in the same situation due to transportation costs on corn into these corn-deficit areas. At various times this season, the price ratios have been even more favorable in these areas and many others to induce large amounts of wheat into livestock feed.

Total wheat used in feed and fed in 1963 was about 32 million bushels, which increased to about 118 million in 1964 and it appears that about 150 million will be used in 1965. It is my belief that to make the substitution clause of the new farm law operative, the basic loan levels of wheat will be set at comparative feed grain levels. With any increased supplies, wheat prices will likely work down to loan rate levels and move large amounts of wheat into livestock feed in some areas of the nation and the world. Thus the new law is quite closely linked to expanded feed use of wheat.

Domestic food use. As you already know, the domestic food demand for wheat is relatively inelastic. This simply means that high or low wheat prices do not seriously affect wheat food consumption very much. With $2.50 wheat, there is only about 3 cents worth of wheat in a loaf of bread, which illustrates that price of wheat contributes little to the manufactured cost of wheat products. It should be noted also that wheat products are one of our cheapest foods even with $2.50 wheat. These basic facts have been proved so often it is astounding to hear all the ruckus raised by the wheat users' committee before passage of the new law. They tried to get the Congress to believe that higher wheat prices would deprive millions of Americans of their economic ability to eat bread. And yet simple economics show us that bread usage is not tied to wheat prices. The cost of wheat to the processor will be the same under the new law as it has been the past few years because the additional cost of wheat for domestic use will be borne by Commodity Credit Corporation rather than by the processor and thus the consumer. Expanded domestic wheat usage depends on better products, a considerable amount of consumer education, and effective promotion.

Industrial wheat uses. The new farm law puts drastic limits on wheat for industrial uses because of the certificate which must be purchased for domestic use. The only wheat product exempt from certificates is "flour second clears not used for human consumption as determined by the Secretary." Presently, this amounts to about 10-million-bushel equivalent of wheat, which partially eases the situation for the starch-gluten industry but is a mere drop in the bucket considering the potential.

The corn milling industry opposed liberalizing the law to permit certificate exemption on all wheat and flour used for industrial purposes. The reasons of course are plain. They wanted to protect their own interest. In the present situation, the only way wheat can gain widespread use industrially is for its starch fraction to be priced competitively with corn starch. New research may uncover uses that will greatly expand the market in which the special characteristics of wheat starch would make it preferable to corn starch at a higher price. So far, this hasn't happened.

The corn milling interests would like to maintain a price relationship between corn starch and wheat starch that is the same as the relationship between wheat and corn. But to do so we encounter the influence of farm programs and if we go back before farm programs, we ignore production technology. The fairest way to analyze the justification for certificate exemption is to establish competitive prices for the starch fractions of each cereal.

The average starch content of wheat is 66 percent and that of corn is 70 percent. On a recent market day using Chicago corn prices at $1.21, the starch fraction in corn would be worth about 3 cents per pound, ignoring the other fraction. On the same market day, yellow hard winter wheat in Chicago sold for $1.42 per bushel making the wheat starch fraction worth 3.5 cents per pound, ignoring the protein. However, the value of the wheat protein would make the starch fractions in both wheat and corn comparatively priced.

Assuming no difference in processing costs and assuming wheat and corn starch could be used interchangeably, a processor would likely be indifferent as to which he used. However, the cost of the certificate which is on top of the $1.42 quickly rules out wheat. With national wheat yields at 26 bushels per acre and national corn yields at 60, it is hard to visualize how wheat starch could seriously jeopardize the corn starch market under prevailing cash market prices, which are operating under fairly free conditions. Wheat is primarily a human food cereal and food use will likely continue to stimulate prices above feed and industrial use levels except in certain instances, such as in corn deficit areas and special markets where wheat starch is preferred over corn starch.

However, if the corn milling industry people are worried about competition from wheat starch, they should note that milo has a higher starch content than corn, is rapidly increasing in acreage, can be produced more cheaply than corn, costs less than corn, and is substitutable for wheat in wheat producing areas and would be produced in greater volumes by these producers than if they produced wheat.

The important point is that research must continue to find industrial uses for wheat where corn cannot fill the requirements. The present certificate requirement practically rules out the economic feasibility of such uses, and the stimulus to continue research on an expanded basis is slacking. It makes it rather difficult to request appropriations for this research when the present farm law rules out all potential because of economics.

The difficulty between corn millers and wheat users can be resolved, I'm sure. Corn industry people have little to be concerned about, if they understand the complete situation. Clearly, wheat interests must become more unified if these barriers are to be let down. I view this as a prime challenge to the entire wheat industry. Research must continue if we are to protect and expand the wheat industry. Legislation to expand the nonfood uses of wheat that is exempt from domestic certificates can be the key.

Export use. Much has been said praising the new farm law as it relates to increasing wheat exports. The law authorized the Secretary to control the pricing of wheat abroad through a system of subsidy payments and export certificate collections. Because loan rates will likely be tied to feed grain levels, the potential for expanding exports is quite good in that domestic prices should approximate world prices. With a minimum of export subsidation needed, criticism from our friendly competitors should not be too severe.

In cash markets we are still handicapped by our inability to trade with Communist countries. The main potential for expanding cash sales lies, in the short run, with the Communist block nations. Expanded exports to solve problems of world hunger and promote peace are perhaps the best overall potential. Legislation has been proposed by Senator McGovern and others to greatly expand food as a tool for international development.

Time does not permit a detailed discussion, but I would like to point out a few pertinent facts: (1) Our investment in Food for Peace markets now will eventually enable the developing nations to be our trading partners and bring us returns worth many times the present cost. (2) Properly investing food into the foreign aid program will require a substantial increase in American production. The program will depend upon a huge volume of readily available food in order to advance its goals of harmonizing world conflict through the elimination of hunger. (3) American farmers cannot be expected to make this investment on their own. It is the nation's obligation and the nation will largely benefit. Therefore, fair prices must be paid to farmers for the products entering this program.

POTENTIALS AND PROBLEMS IN HYBRID WHEAT

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The DeKalb Agricultural Association, Inc., started a program to hybridize wheat in 1959 after seeing the report of Dr. Kihara from Japan which was presented at the 10th International Congress of Genetics a year earlier. This work was intensified and expanded in 1961 with the addition of Dr. J. A. Wilson from the Kansas Agricultural Experiment Station. More recently, E. C. Gilmore and Dr. Gregorio Vazquez have joined Dr. Wilson in this research effort.

After three years of extensive testing, it is apparent that hybrid vigor can produce the same results in wheat that it has in corn and sorghum. The yield increases for hybrids range from a minus 34.2 to a positive 53.5 percent when compared with the best-yielding parent. Every market class of wheat tested has exhibited encouraging results.

Quality studies are equally encouraging. Using micro-evaluation techniques, DeKalb scientists report F1 hybrids to be intermediate between the two parents in the quality tests. The protein readings vary, but hybrids of hard red spring types tend to equal their parents. One particularly interesting cross outyielded the better parent by 24.4 percent and also had a slight increase in protein. The data indicated that hybrids with adequate baking quality can be obtained.

Although yield and baking-quality data are favorable, there are some problems. Since the wheat plant has a perfect flower, breeders must use a cytoplasmic sterility-restorer system to make hybrids. The best system to date was discovered in Triticum timopheevi, a close relative of wheat. A number of varieties and types in all major classes of wheat have been converted to male sterility. Experience shows that there is much more difficulty in concentrating sufficient restorer genes to give fully self-fertile plants. A number of restoration genes seem to be involved, and lines must be test-crossed to determine if a full complement is present. Environment also seems to affect the sterility-restorer system. Inbred lines which were sterile in the greenhouse showed partial fertility in the field in Mexico, but were again sterile when planted in Montana. Restorer lines were also influenced by environment.

In the final analysis, seed cost will determine the feasibility of hybrid wheat. The yield increase must be large enough to justify the purchase of hybrid seed. At the same time, seed producers are faced with the challenge of making and distributing wheat hybrids at the lowest possible cost.

INDUSTRIAL USES OF WHEAT AND FLOUR

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As a food, wheat has realized a higher market value than corn, sorghum, and other feed grains. This higher price has resulted in only minor use of wheat and wheat flour for industrial purposes, except in periods of national emergency. Three market periods will be considered: past, present, and future. The past and present are known. Future markets may well be increased by as yet undiscovered research findings and can materially be affected by production capacity, world events, national controls, and emergencies.

Past markets. Before World War II, there were small but hardly significant industrial uses for wheat. About 500 million bushels annually were milled for food and more than 100 million were used for feed (Figure 1). During World War II (1942-1945), however, attention turned to wheat because the demands for corn exceeded the supply for livestock feed, industrial alcohol, starch, sweetening agents, and many other necessary products. Wheat was available, and through research, processes and procedures were developed to use it. Industrial consumption increased rapidly, and in 1943 some 100 million bushels (equivalent) were consumed. At the same time, feed uses greatly increased, and at one time were actually larger than food uses--reaching a peak of about 500 million bushels. The price of wheat during this emergency period had minor importance. The end products were almost a must, regardless of cost.

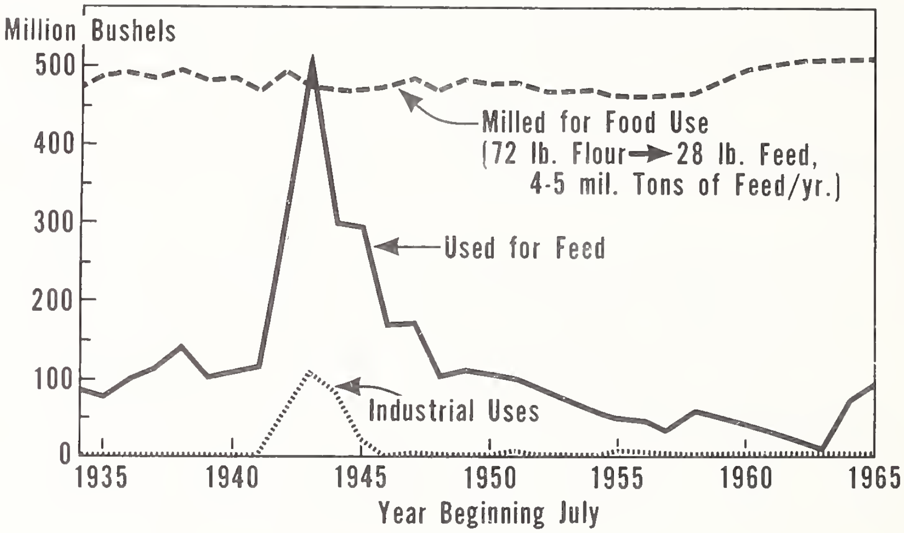

Figure 1. Utilization of wheat in US.

At the end of World War II, economics again became a prime factor. Wheat and wheat flour lost most of their industrial markets and became minor in importance as industrial raw materials. This situation is still true today.

The Northern Laboratory was a major contributor to the developments that made the volume of industrial use of wheat possible during the war emergency period:

1. A wheat wet-milling process was developed, and about 3 million bushels of wheat grain were processed by it. About 33 pounds of starch were recovered per bushel. The gluten produced was devitalized but was suitable as feed protein and for the manufacture of monosodium glutamate--a flavor enhancer. The byproduct fiber and oil meal were marketed as feeds.

2. The "batter process" was developed to convert wheat flour into starch and gluten. This relatively simple process in which starch is separated from gluten by washing at one time used more than 300 million pounds of wheat flour annually. The starch produced, in addition to direct end use, became a major raw material for the production of syrup, dextrose, and sugar. Some of it was further converted into industrial alcohol through fermentation. The vital gluten fraction was a raw material for fortifying bakery products or was devitalized for the manufacture of monosodium glutamate.

3. Wheat was a major raw material for the production of ethyl alcohol through fermentation. Alcohol was essential for the manufacture of munitions and synthetic rubber. Approximately 2.5 gallons of anhydrous ethyl alcohol could be produced from a bushel of wheat. The Northern Laboratory coordinated a combined research effort of industrial corporations, commercial laboratories, universities, and Federal research agencies to determine how to best use wheat for this purpose. We estimate that at least 250 million bushels of wheat were consumed in the manufacture of ethyl alcohol by fermentation.

Although necessitated by war-time conditions, these developments demonstrate what could be done technically to use a new raw material (in this case, wheat) for the production of important industrial products.

Present markets. Only relatively small amounts of wheat and wheat flour are at present consumed industrially. Corn, sorghum, and tapioca are available in more than adequate supplies. Many of these are priced lower than wheat, at least for general use. Some of the past industrial markets for cereal grains have been lost. For example, industrial ethyl alcohol now is practically all produced synthetically from petroleum. The major industrial uses for wheat flour at present are as follows:

1. As extenders for plywood and laminating urea-formaldehyde adhesives where a light color or a white glue line is desired. A flour containing about 13 percent protein is preferred. The protein in the flour has a definite effect on glue viscosity. Approximately 90 pounds of flour are used per 100 pounds of 65 percent urea-formaldehyde resin. We estimate that about 125 million pounds annually are consumed.

2. In composition-board resins wheat flour imparts properties similar to the plywood adhesives. We estimate an annual market of about 25 million pounds.

3. In the production of wheat starch or special flours by the batter process or similar processes, about 265 million pounds are used annually. The amount of wheat starch produced by the wet-separation process and directly

consumed in industrial uses is uncertain. Our estimate is about 80 million pounds (Table 1).

Table 1.--Estimated industrial uses of wheat starch in 1965

Use	Starch used million pounds
Laundries	13
Paper laminating and corrugating	24
Adhesives	10
Textiles	11
Wall paper and billboard paste	20
Miscellaneous	2
Total	80

In bushel equivalents, the total is about 12.5 million bushels. As a range, the consumption would be between 10 and 15 million bushels annually. Most of the wheat flour and starch is produced from low-grade or damaged wheat or from byproducts or less desirable flour fractions from the milling industry. Certainly, economic considerations are factors in these industrial end uses even though the special properties of the wheat components are desired.

Future markets. More cereal grains are now being used for industrial purposes than ever before. Almost 2 billion pounds of cereal starches alone are used by industry annually, an increase of more than 300 percent during the past 30 years. Yet, wheat has not shared in this industrial growth. How can this unfavorable trend be changed?

As previously shown, through research, commercial developments rapidly followed in wartime when economic factors were favorable. At present, specific properties result in certain industrial uses. The composition of important cereal grains is listed in Table 2. In gross composition, corn, wheat, and sorghum are comparable. If wheat or its components are to be used, even though more expensive than other cereal grains, their special or unique properties must be utilized. We might look, now, at some of these properties.

Table 2.--Average percentage composition of surplus cereal grains[1]

Grain	Starch	Protein	Oil	Fiber	Minor constituents[2]
Hard wheat	64	14	2	2	18
Soft wheat	69	10	2	2	17
Dent corn	72	10	5	2	11
Sorghum	71	13	3	2	11

[1] Moisture-free basis.

[2] Minerals, sugars, pentosans, vitamins, etc.

Figure 2 is a microscopic comparison of sorghum, corn, and wheat starch granules. An idea of size of these granules may be realized in that 1 pound of corn starch contains about 700 billion granules. Wheat starch contains a larger number of smaller granules than corn or sorghum starches. Their size range and pure whiteness explain why wheat starch is often preferred for laundry use; the

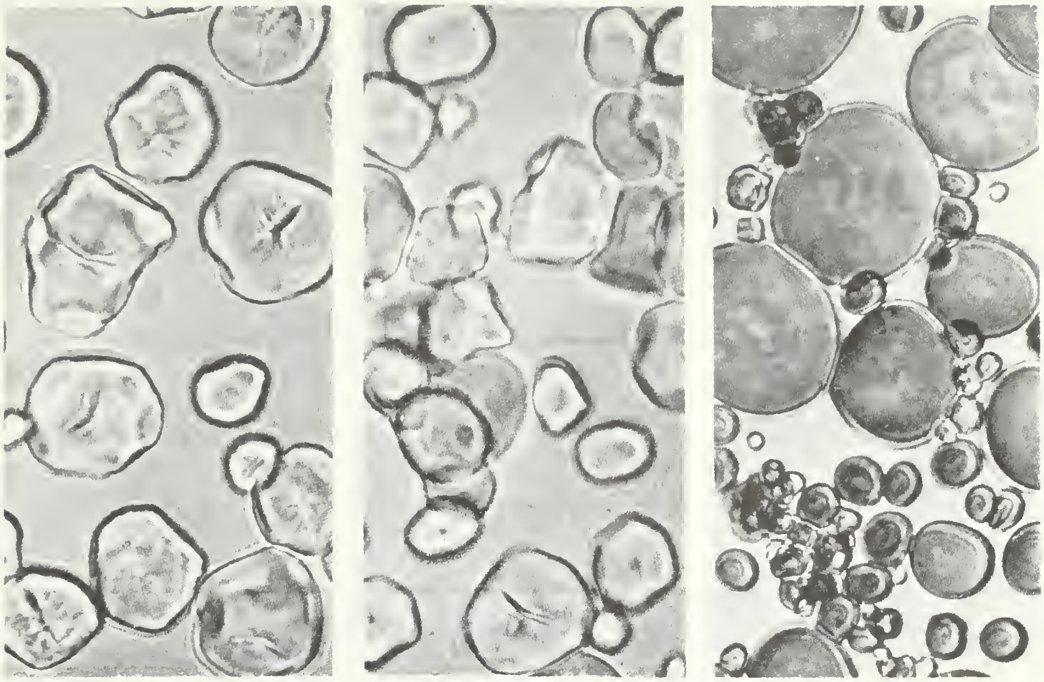

Figure 2. Sorghum, corn, wheat.

small granules are believed to penetrate fabrics and, in addition, produce a softer feel. Likewise, the slipperiness and high water retention of wheat starch make it better for wallpaper paste.

The physical properties of wheat gluten differ greatly from those of corn or sorghum gluten. Wheat gluten has unique hydration, extensibility, and elasticity properties not available in other cereal grains. Consequently, wheat gluten has a potential plus value for the development of specific industrial markets. Adhesives, coatings, and paper sizings are typical of these markets. Elastic foams have been made by copolymerizing gluten and a urethane (organic chemical).

If the costs of the wheat and of the processing are distributed equally over all of the separated fractions, wheat starch would normally be more expensive than other cereal grain starches. If, however, one or more of the fractions can be sold at a higher price and carry more of the cost, the remaining components may be reduced in price so as to compete. The batter process is typical of this type of operation. The vital gluten fractions (containing about 78 percent gluten) can be marketed at 4 or 5 times the cost, per pound, of 2nd clears. The higher gluten value, in turn, makes it possible to sell the starch at a cost close to the general starch market prices. The use of wheat flour for producing vital gluten has expanded an estimated 100 percent in the past 10 years.

The relatively new milling technique of fine grinding and air classification offers possibilities for adjusting the composition of wheat flour. Finely ground dry flour is fed onto a rotating plate. The flour is thrown outward by centrifugal force and against a stream of air. Through careful control the coarse particles are not significantly affected by the air. The fine particles are picked up by the air, however, and removed through another outlet. A typical fractionation of a Northwest Gaines wheat flour is shown in Figure 3.

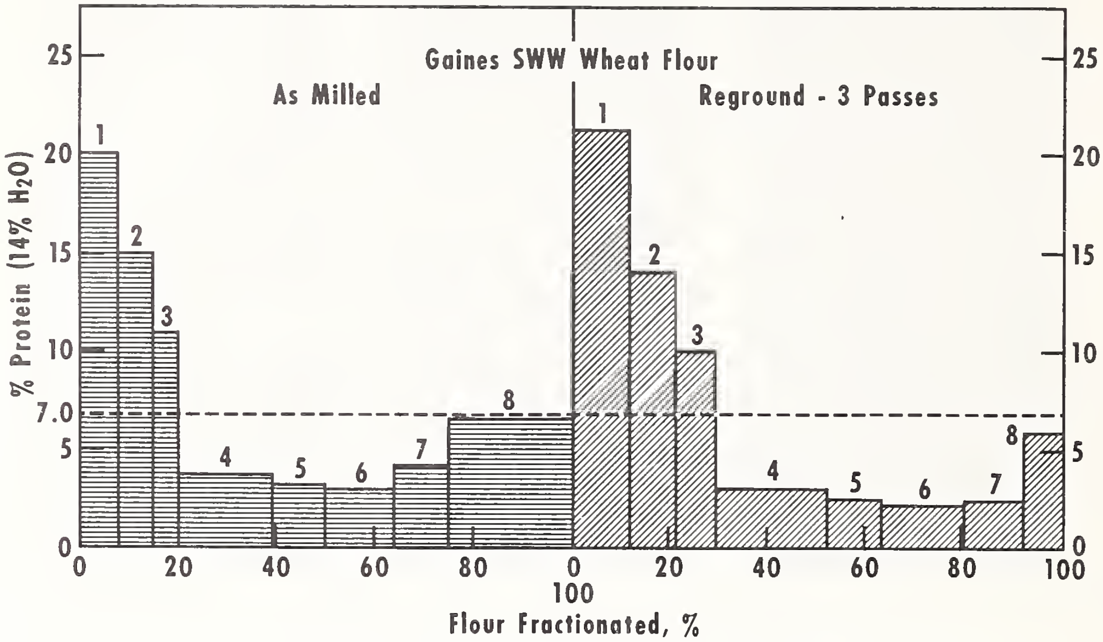

Figure 3. Gaines SWW wheat flour.

From an original flour containing 7 percent protein, fractions have been obtained containing as high as 20 and as low as 3.1 percent protein. The low-protein fraction may be a good industrial product for many uses based on starch. For example, preliminary tests in the paper industry have indicated it to be suitable for internal paper size. The high-protein fraction from certain wheat varieties is an excellent blending flour for fortifying or adjusting the protein content of other flours. This premium value may under certain conditions make it possible to pay the added processing costs and yet lower the price of the starchlike fractions so that they can compete in industrial markets. A comparison of fractionation responses from typical wheat flours is summarized in Table 3. All wheats do not respond the same.

Table 3.--High- and low-protein fractions separated from various flours

Wheat flour		% Protein in fraction High-protein	Low-protein
Omar	WC (6.0% P.)	17.0	2.2
Brevor	SWW (6.5)	25.1	1.3
Michigan	SWW (7.9)	20.2	2.8
Illinois	SRW (9.8)	23.5	4.6
Midwestern	HRW (12.2)	25.8	6.9
Northern	HRS (13.3)	26.4	7.8

Chemical modification of flour so as to take advantage of the starch and gluten properties is another approach for the development of industrial wheat products. Modification can be directed either toward general improvement, for example, of solution properties or toward capitalization on the properties of both starch and gluten, both of which would be modified favorably. Acid affects the properties of a flour-water mixture heated to the boil and cooled. Untreated flour forms a stiff gel at a 5-percent concentration, whereas the paste of acid-treated flour flows readily. When tested in paper, the strength properties of a paper sized with acid-modified flour compare favorably with a hypochlorite-oxidized starch, one of the best commercial products now used for sizing paper.

Similar results can be obtained by other chemical methods of modification. Wheat flour can be readily reacted with ethylene oxide to form hydroxyethylated flour. An untreated 8-percent paste of wheat flour, for example, sets to a rigid gel. In contrast, a similar dispersion of hydroxyethylated wheat flour flows readily with more than three times the amount of solids dispersed.

A most promising development for using wheat products in the paper industry, including ground whole wheat, wheat flour, and millfeeds, is through what we call cereal xanthides (often referred to as cereal pulps). When the cereal fraction is reacted with carbon disulfide and sodium hydroxide under controlled conditions, a gumlike material called xanthate is produced. The xanthate is water soluble. When an oxidizing agent is added to the xanthate solution, it changes to a water-insoluble compound called cereal xanthide. If the xanthate is added to wood pulp and then converted to the insoluble xanthide, a uniform mixture is formed that can be made into paper. The general procedure is shown in Figure 4.

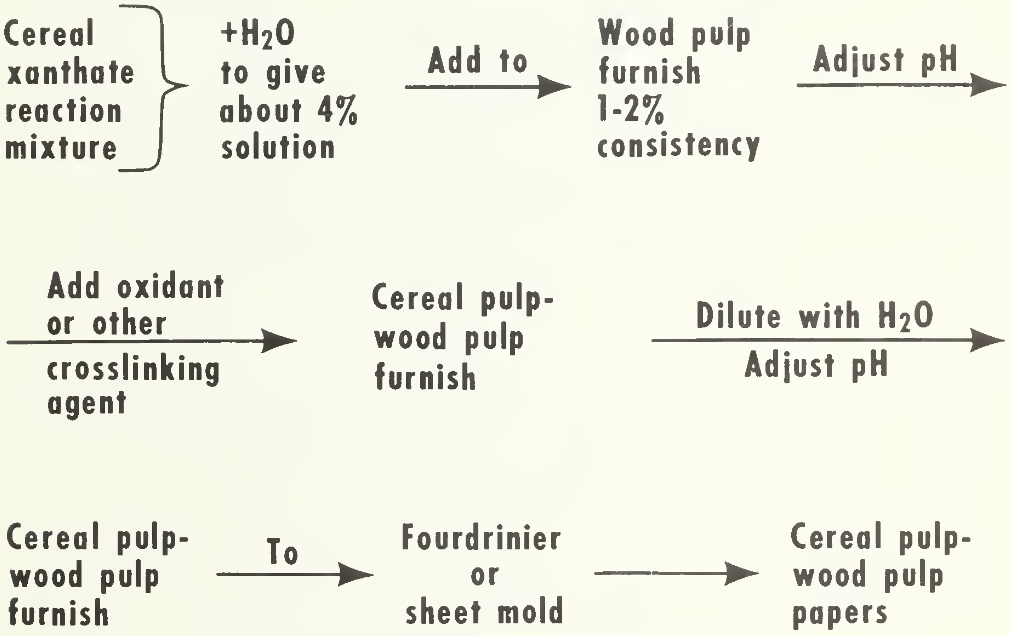
Cereal xanthate reaction mixture
+H₂O to give about 4% solution
Add to
Wood pulp furnish 1-2% consistency
Adjust pH
Add oxidant or other crosslinking agent
Cereal pulp-wood pulp furnish
Dilute with H₂O
Adjust pH
Cereal pulp-wood pulp furnish
To
Fourdrinier or sheet mold
Cereal pulp-wood pulp papers

Figure 4. Incorporation of cereal xanthate in paper.

Properties of the experimental paper containing starch xanthide have been plotted in Figure 5. Compared with the control, wet strength of the experimental paper is greatly increased. Possibly even more important is its increase in wet stiffness. Wet stiffness is urgently needed in linerboard for corrugated boxes for the shipment of wet materials (such as vegetables or fruits) or where high-humidity conditions exist.

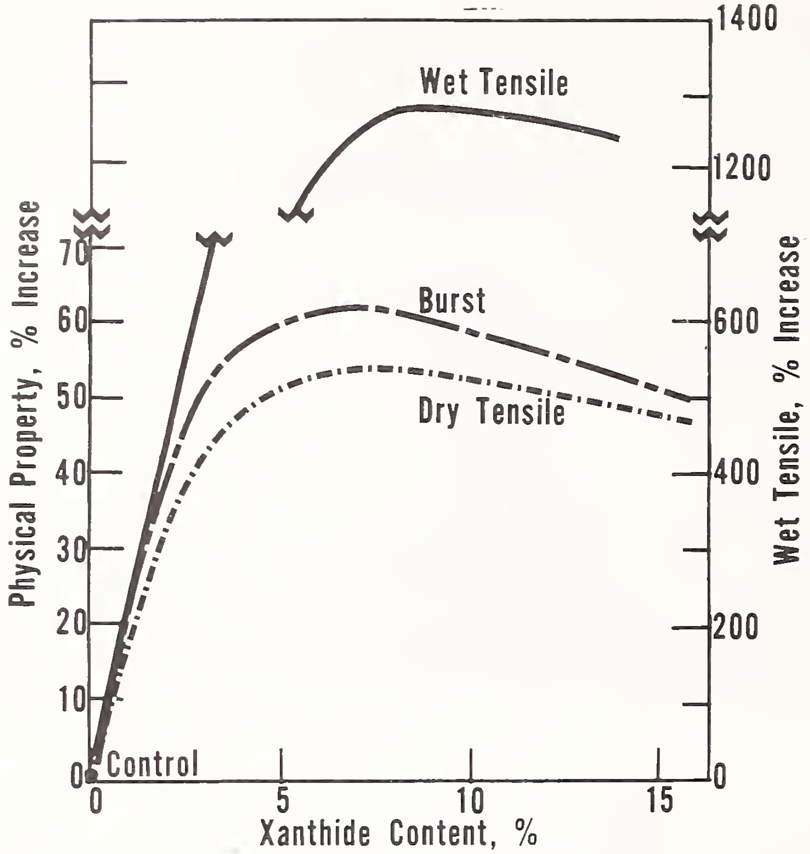

Figure 5. Effect of starch xanthide content (DS 0.13) on linerboard.

The future of cereal xanthides remains to be resolved, but large possibilities can be visualized from the magnitude of the paper industry today. When we consider that the overall average of cereal (primarily starch) now used in all paper is only about 1.5 percent, equivalent to about 1.25 billion pounds annually, even a small percentage increase is equivalent to millions of bushels of cereal grains.

The possibility of using specially milled whole or debranned wheat flour as an internal paper or linerboard size is now being extensively investigated. A cooperative study between Washington State University and the Northern Laboratory is under way. Preliminary results from this study were presented at the Third Wheat Utilization Conference last year. Additional commercial tests are planned, pending establishment of optimum milling and processing conditions.

The chemical and/or mechanical processing of wheat or wheat flour for industrial uses have been considered so far in this discussion. However, for the future the new high-yielding wheat varieties could change the complete economic situation. Possibly certain wheat varieties will be grown for industrial raw materials only and will not be used for food. It is still too early for definite predictions.

Summary. From past experience, we know that from a physical and chemical standpoint wheat is a suitable raw material for industrial uses. Its major drawback has been price, normally higher than that of other available grains.

The unique properties of wheat starch and wheat gluten now provide limited industrial use. Exploitation of these properties thorugh physical and chemical modification offers a way for the development of more industrial markets. A wide range of flour types differing in starch and protein content is now available through new milling processes. New wheat varieties may prove economical to grow for industrial use only.

Fundamental research is necessary to supply the information and know-how for successful applied research developments. A concerted effort by everyone interested in industrial markets for wheat is required for success. The rate of progress will depend on the total effort.

UPGRADING WHEAT FEEDS

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There is no question about our ability to use some wheat and millfeeds in animal rations as partial replacements for corn or other grains. The questions are, how much can be used and exactly how much are wheat products worth compared with competitive grains when used for different types of animals under varying conditions, with varying ration composition? The first obvious step in evaluation is to compare analyses of grains or millfeeds. We know quite a lot about composition. Table 1 shows some data comparing wheat and corn. The most important differences are in protein, metabolizable energy, and xanthophyll. These can be compensated for by adjusting other ration ingredients. Thus, wheat and corn rations can be devised which, based on analysis, should give the same results. Do they? The answer is, "Not always." And the performance advantages, if any, in a given experiment (Table 2) are usually, but not always, in favor of the corn. This applies to millfeeds and barley as well as wheat.

These discrepancies between calculated and actual results lead to the idea that in spite of the large amount of information on hand we still do not know enough about composition, and more important perhaps about nutrient availability, to predict what a ration will do in the animal. The discrepancies cited and empirical observations lead to the idea that there is a potential for improving the value of wheat, or "upgrading" it through processing, or through attainment of knowledge whereby more effective use can be made of a commodity. These two approaches are mutually supplementary and would benefit the wheat industry by producing higher returns or by broadening markets through improving competitive position in relation to other commodities.

A considerable amount of empirical research has been done to upgrade both wheat grain and millfeeds. The present paper reviews briefly some specific work with both poultry and ruminant feeding. Next it defines some specific areas of research needed to find out the basic causes for improvements observed and to apply such basic knowledge to still further improvements and control of present processes to give optimal results consistently. Finally, this paper presents results of some work we have under way in the Western Utilization

Table 1.--Comparative feedstuffs analysis for wheat vs. corn (Oregon State University, Feedstuffs, May 30, 1964, page 44)

Nutrient	Amount	
	Wheat	Corn
Protein, %	12.7(9.6)	8.9(8.3)
Fat, %	1.7	3.9
Fiber, %	3.0	2.0
Metabolizable energy, Cal/lb	1405.0	1560.0
Calcium, %	0.1	0.0
Phosphorus, %	0.4	0.3
Manganese, mg/lb	24.9	2.2
Sodium, %	0.1	0.0
Iron, mg/lb	27.0	13.0
Copper, mg/lb	3.7	1.8
Iodine, mg/lb	0.02	0.02
Potassium, %	0.6	0.4
Magnesium, mg/lb	817.0	771.0
Zinc, mg/lb	7.0	5.5
Vitamin A activity, USPU/lb	0.0	1500.0
Riboflavin, mg/lb	2.4	0.6
d-Pantothenic acid, mg/lb	6.2	2.7
Niacin, mg/lb	28.9	12.1
Choline, mg/lb	424.0	284.0
Vitamin B_{12}, mcg/lb	0.5	1.5
Vitamin E, IU/lb	8.7	15.4
Pyridoxine, mg/lb	2.4	3.8
Folacin, mg/lb	0.2	0.1
Biotin, mg/lb	0.05	0.03
Thiamine, mg/lb	2.5	2.1
Arginine, %	0.8	0.5
Cystine, %	0.2	0.1
Glycine, %	1.0	0.5
Histidine, %	0.3	0.2
Isoleucine, %	0.6	0.5
Leucine, %	1.0	1.1
Lysine, %	0.5	0.2
Methionine, %	0.2	0.2
Phenylalanine, %	0.7	0.5
Threonine, %	0.4	0.4
Tryptophan, %	0.2	0.1
Tyrosine, %	0.5	0.5
Valine, %	0.6	0.4
Xanthophyll, mg/lb	1.5	10.0

Research and Development Division which we feel will contribute to the desired objectives.

The "water treatment" problem. It has been found, as described previously (J. McGinnis, ARS-74-31, Report of Third National Conference on Wheat Utilization Research, 1964), that treating whole or ground barley or wheat with water

Table 2.--Wheat vs. corn in broiler rations (G. S. Arscott, quoted in Feedstuffs, Nov. 28, 1964, page 31)

	Average for eight weeks				
Treatment	Body wt.	Feed cons.	Feed conv.	Water cons.	Shank score
	lb.	lb.		lb.	
Wheat mash	3.29	7.80	2.38	12.2	3.0
Corn mash	3.51	7.66	2.18	11.5	7.3

and simply redrying causes substantial improvement in growth rates of poultry and in efficiency of feed conversion. Table 3 shows that wheat and barley so treated are at least equal to corn. Further work, much of which was done under a USDA contract at Washington State University by J. McGinnis and coworkers (cited above) has shown: (1) that additions of certain enzyme preparations can partially, but not completely, replace the water-treatment (WT) upgrading effect; (2) that the effect is related to the geographic source of the wheat or barley; (3) that similar upgrading effects are obtained with millfeeds as with whole ground grains; and (4) that the effect is probably due, at least in part, to growth of microorganisms in the products which was producing enzyme plus a growth promoting antibiotic (see Figures 1 and 2). Thus, as is shown in Table 4, the superiority of eastern grain over western grain could be eliminated by autoclaving (which would inactivate the enzymes). When bacterial enzymes were added back to the autoclaved eastern and western barleys, essentially identical growth rates were obtained. Finally it was shown at the Washington Station that the improvements were probably related to increased availability of energy from

Table 3.--Effect of water treating of grains on their nutritional value for poults (Fry et al., Washington State University, 1958)

	Water treated	3 Week weight
Corn	-	419
Barley	-	292
Barley	+	408**
Wheat	-	398
Wheat	+	437*
Rye	-	236
Rye	+	292**

* Significantly different (P <.05) from untreated control.

** Significantly different (P <.01) from untreated control.

Table 4.--Effect of wet autoclaving of eastern and western barleys on response to enzymes

Treatment	Eastern	Washington barley
None	122	107
Fungal enzyme (2 gm/lb)	132	139
Autoclaved	95	91
Autoclaved + enzyme	131	137

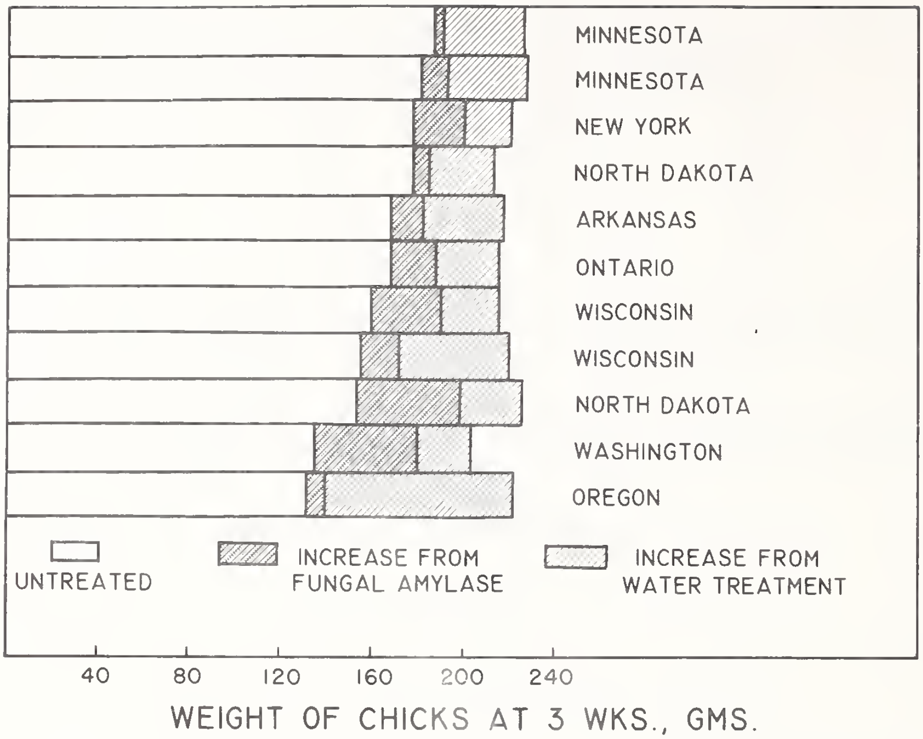

Figure 1. Effect of geographic source of barley on chick growth responses to to enzyme supplementation or water treatment.

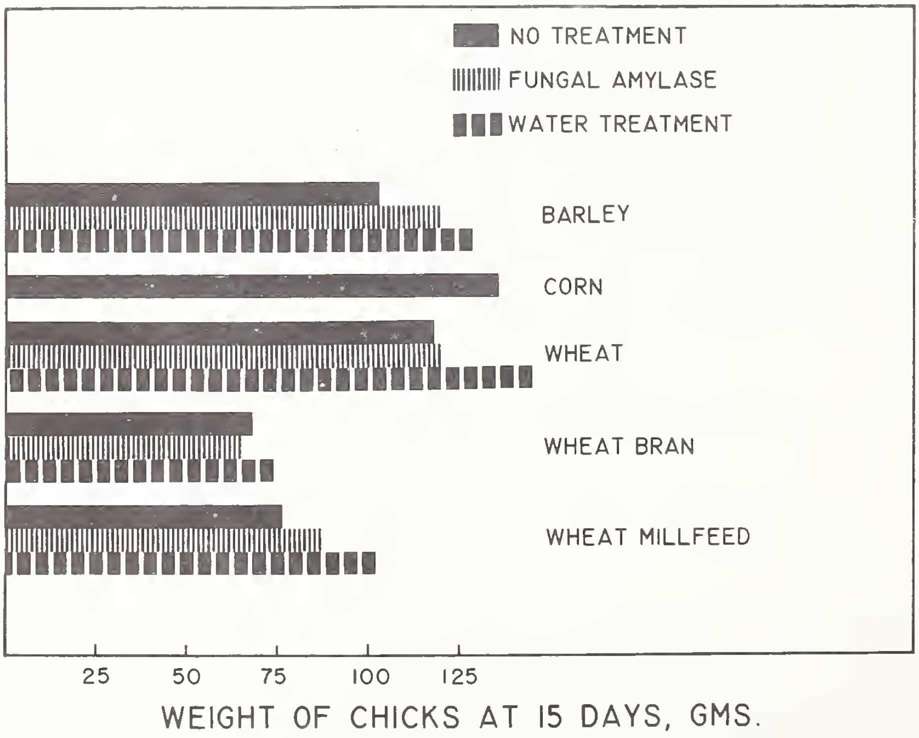

Figure 2. Effect of water treatment or enzyme supplementation of grains and millfeeds on chick growth responses.

the treated grains. This conclusion is based on direct measurements of metabolizable energy.

This all seems to add up to a neat picture. However, recent work at the Ohio Agricultural Experiment Station (Feedstuffs, June 5, 1965, page 52) showed that pure potato starch responded to water treatment at temperatures below which gelatinization occurs and that the improvement due to water treatment of hard red wheat did not seem to depend on fermentation. They showed that water treatment affected all turbomilled flour fractions favorably, but the high starch fraction was the only one affected as much as whole flour. Thus, the effect is on the starch fraction.

From all this we can conclude that water treatment causes improvement by making more grain energy available for poultry. This effect could be due to enzyme-resistant bonds in either the starch or in the gums which occur in the starch fraction. That gums might be involved was indicated by the work of L. S. Jensen (Feed Age 14(1): 28, 1964) and of P. Vohra and F. H. Kratzer (Poultry Sci. 43: 1164, 1964). At any rate, it is clear that more basic chemical investigation of such enzyme-resistant linkages of wheat are needed to provide the basis for optimum practical treatments to upgrade wheat. Enzyme supplementation of rations for cattle and swine has at times produced positive results while in other cases no improvement was noted (J. E. Oldfield, Feedstuffs, Nov. 12, 1960, page 78; I. A. Dyer, Feedstuffs, May 25, 1963, page 36; Yang, Bush, and Odell, J. Agr. Food Chem. 10: 322, 1962). A part of the problem is to find out why this variability occurs.

Pelleting effects. Pelleting of feeds has been developed because the overall effects have been to increase growth rates and feed efficiency of poultry, cattle, and lambs (A. G. Cave, on chicks, in M.S. Thesis, University of Guelph, Ontario, 1965; W. H. Hastings, Feedstuffs, Jan. 21, 1962, page 58). It was initially thought that the improvement might be due to improved intake due to increased bulk density, improved palatability due to reduction in dustiness, and more desirable "texture." However, as the results in Table 5 show, when the texture and bulk density are restored through regrinding pellets, the differences persist in favor of the processed material. It therefore can be concluded

Table 5.--Effect of pelleting and regrinding rations on performance of turkey poults (Allred, Jensen, and McGinnis, Poultry Sci. 36: 517, 1957)

Energy of basal	% Fat added	Form	Av. wt. 4 weeks	Feed efficiency	Density
			gm		gm/ml
High	0	Mash	566	1.77	.70
High	0	Ground pellet	607	1.61	.65
High	3	Mash	624	1.64	.68
High	3	Ground pellet	642	1.61	.65
Low	0	Mash	495	2.01	.63
Low	0	Ground pellet	585	1.80	.64
Low	3	Mash	560	1.80	.59
Low	3	Ground pellet	585	1.71	.63

that at least a large part of the improvement from pelleting is due to chemical change, possibly inactivation of an inhibitor or increased digestibility of some fraction. Direct evidence showing improvement of metabolizable energy (ME) of wheat millfeeds due to pelleting has been obtained at the Ontario Agricultural College (Cave, cited on previous page). Steam pelleting increased the ME of bran by 30, of shorts by 17, and of wheat germ meal by 15 percent. Other effects of pelleting were increased by feed consumption, increased apparent digestibility of protein and fat of the germ, and of the protein of bran.

Cooking and expanding processes. A full-day meeting recently was devoted entirely to these types of grain processing as related especially to cattle feed results. In reporting this meeting, Roger Berglund (Feedstuffs, Sept. 18, page 1, and Oct. 2, page 6, 1965) commented, "Questions of the technical 'whys' almost more than 'how' or 'what' of steam processing of grain for beef cattle on feed would indicate that the rumen is still a rather dark place." Older methods of rolling and crimping grains were developed largely based on palatability to the animals. Some research over the past decade has shown that proper steaming as pressure cooking prior to rolling or flaking can increase feed efficiency of beef cattle by 5 to 10 percent (L. S. Pope, Feedstuffs, Jan. 13, 1963, page 40). Many thousands of tons of cooked grains are fed to cattle throughout the West, but we do not know why the improvement takes place nor how to control the process being used for optimum results. The same is true of the upgrading of nutritional value of wheat during bulgur manufacture. Figure 3 shows the improved chick growth due to cooking and also the reversal of this effect caused by mild puffing (G. O. Kohler, Cereal Sci. Today 9: 173, 1964). One effect which is probably involved in the cooking is a known effect on starch. Starch as it occurs in grains and other natural products is in the form of tiny balllike bodies called starch granules. This starch is partially crystallized in nature. When we add water it is imbibed by the granules and then application

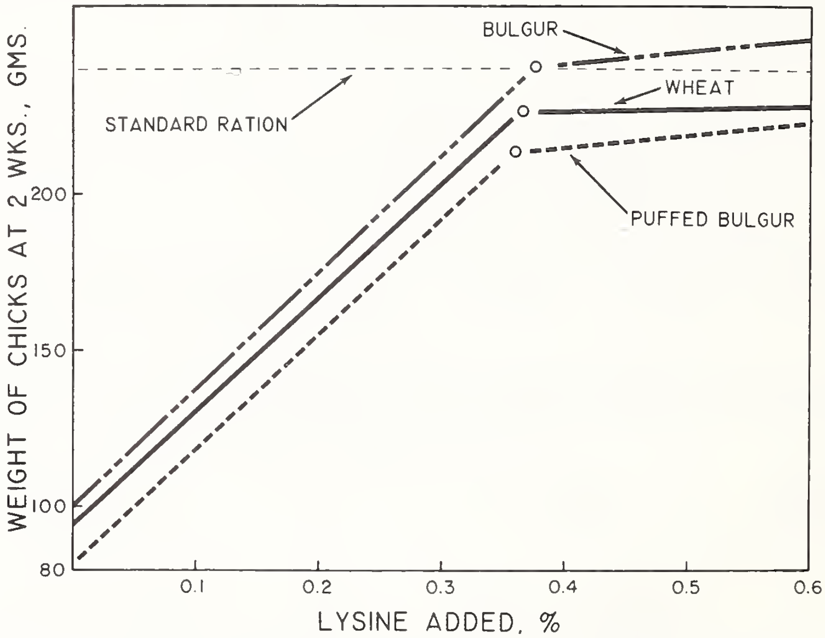

Figure 3. Effect of feeding wheat, cooked wheat (bulgur) and puffed cooked wheat on growth of chicks fed rations containing varying levels of lysine.

of heat causes the granule structure to break down as the starch forms a noncrystalline gel. Hence the name "gelatinization" is used to describe this loss of structure. It has long been known that starch-splitting enzymes work much more slowly on natural starch than on gelatinized starch. Thus part of the cooking effects may be due to gelatinization.

Another material in wheat sensitive to heat is the growth inhibitor in the germ, which was described by Creek *et al*. (*Poultry Sci*. 40: 822-23, 1961). Table 6 shows effects of feeding a high level of wheat germ to chicks on weights, liver weights, and pancreas weight. The growth-depressing effect of the germ was eliminated by autoclaving (steam processing the wheat germ for 30 minutes at 15 psi). Indications have been obtained from chick studies to the effect that wheat middlings similarly respond to autoclaving (R. D. Creek, *Northwest. Miller*, May 28, 1962, page 44; *Feedstuffs*, April 21, 1962, page 38). It is not known whether the same factors are involved in either the cattle studies and chick studies or whether the heat and shear produced by pelleting are producing the same effects as cooking with higher levels of water present. More work will be necessary to determine the interrelationships.

Table 6.--Effect of feeding raw and autoclaved wheat germ meal on liver and pancreas weights (Creek *et al*., *Poultry Sci*. 40: 822-23, 1961)

Group	Treatment	Average body wt. (g)	Liver mg/g body wt.	Pancreas mg/g body wt.
1	Control	213	40.5	4.99
2	+ 55.5% WGM	190	50.7	5.41
3	+ 55.5% WGM (autoclaved)	223	45.6	5.22

Still another reaction which goes on during heating of wheat is denaturation of its protein. This effect is similar to coagulation of egg white which occurs on boiling. In general, denatured proteins are more easily split by enzymes of the digestive tract than native proteins. Also, many toxic proteins are detoxified by cooking as, for example, the poison of castor beans. But when protein is heated in the presence of reducing sugars, some essential amino acids are tied up so that a negative effect may take over under some conditions. Table 7 shows the results of pelleting on the essential amino acids (for the chick) of wheat millrun (R. Palter and G. O. Kohler, unpublished data). You will note that only slight differences were found in amino acid composition. Arginine dropped a little but lysine, considered to be most susceptible to heat damage, was not affected in this experiment. The figures in parentheses refer to available lysine and this, too, was unchanged by pelleting. This work was done in cooperation with Washington State University and several milling companies of the Pacific Northwest. The pelleting was done at Washington State and may not have been representative of larger commercial operations. More research is needed along these lines.

Another approach we have been taking to find out what goes on during upgrading is to study the insoluble carbohydrates and lignin of wheat and millfeeds. Here we have found that established method is not capable of detecting the subtle chemical differences which must be responsible for the relatively large upgrading effects observed in animal tests. For example, we (Guggolz, Table 7.--Effect of pelleting on essential amino acids of millrun from HRS wheat

	Not pelleted	Pelleted and reground
Lysine	4.0(3.9)*	3.9(3.9)*
Arginine	6.5	5.9
Threonine	3.1	3.1
Glycine	5.3	5.2
Cystine	2.3	2.1
Methionine	1.8	1.5
Valine	5.0	4.9
Isoleucine	3.4	3.4
Leucine	5.8	5.8
Tyrosine	2.4	2.0
Phenylalanine	3.8	3.8

* ( ) = available lysine determined by DNFB.

Herring, Kohler, unpublished data) have found no effects of pelleting (again under noncommercial conditions) on cellulose, lignin, pentosans, crude fiber, or protein contents of millrun. We have observed interesting changes in some other fractions of wheat, but at this stage these changes constitute promising leads rather than a solution.

In conclusion, it may be stated that there is abundant animal evidence that various moist heat treatments can upgrade the nutritive value of wheat as well as of other grains for both poultry and ruminant animals. Indeed, cooking grains for ruminants is commercially practiced on a large scale in the western States. Pelleting with steam injected into the mill is widely used on poultry feeds. However, overcooking or overheating is detrimental to nutritive value. Although biological availability of carbohydrates is involved, the subtle chemical changes which result in upgrading and reverse effects of overcooking are not understood. Research is needed on the basic reactions involved so as to develop superior processes with better control over process variables. Wheat and barley are improved more than corn by the processes discussed, and, hence the relative economic position of these grains and wheat millfeeds as feeds will be improved by further research in this area.

RESEARCH ON FEEDING WHEAT TO CATTLE

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Wheat has taken on new importance in livestock feeds during the past two years. Yields of well over two tons of total digestible nutrients per acre from new varieties of soft wheat have provided the Pacific Northwest (as well as other areas) with a tremendous livestock feeding potential. The new wheat program initiated within the last two years brought wheat prices into the feedgrain range for the first time since the 1930's.

Wheat is an excellent feed for fattening hogs, and when competitively priced it is used extensively by swine producers. Wheat is very good for fattening lambs when fed in a mixture with other grains. Wheat has not been used extensively for fattening cattle because of price. Now that wheat is competitive, the question may well be asked, how effective is wheat in a high-energy beef ration? Although this grain has been under investigation as a livestock feed since the turn of the century, little has been done to determine its real value in finishing feeds.

A comparison of the physical and chemical properties of wheat and barley reveals they are quite similar except for the crude fiber content. Barley contains about 5.7 percent crude fiber of which only 46 percent is normally digested. Wheat contains 2.7 percent crude fiber of which 90 percent is digested. It is interesting to note that dried molasses beet pulp (DMBP) has 15.2 percent fiber of which 80 percent is digestible. The crude fiber of the ration provides bulk. This bulk is important to prevent the formation of dough-like masses in the rumen that inhibit fermentation and bacterial action. Bulk also serves to distend the digestive tract, which is desirable for effective elimination of waste products.

When the University of Idaho was first encouraged to do research on the feeding of wheat to cattle, little information was available in the literature. Since that time, however, other experiment stations have reported results on wheat feeding. For example, in recent trials at Oregon State University Dr. A. T. Ralstin reported on two experiments, each using 216 steers. Some of his findings were: (1) Wheat can be used in our modern high-energy finishing rations for beef cattle. (2) Optimum results were obtained when the crude fiber content of the total ration was between 4 and 10 percent. (3) Wheat can satisfactorily constitute 90 percent of the total ration. (4) Wheat's greatest advantage seems to occur at about 60 percent of the total ration. (5) The value of wheat (with 7 percent rye) was $50.51 per ton compared with barley at $49.00 per ton.

Recently USDA scientists at Beltsville, Maryland, found that both rate of gain and feed efficiency were reduced when wheat made up more than 60 percent of a total finishing ration. Cattle fed an all-corn ration gained one-half pound a day more than cattle fed an all-wheat ration.

Idaho trials comparing wheat and barley. In the fall of 1963, 60 heavy Angus steer calves were started on a 174-day trial at the Caldwell Branch Station. During the first 84 days the calves were fed all the roughage they would eat plus 4 pounds of concentrate daily. Later they were given a 90-day all-concentrate finish. The roughage was 6 parts corn silage and 1 part alfalfa hay. The all-concentrate rations used are shown in Table 1.

For the sake of brevity only three rations are considered. Each lot contained 10 steers fed one ration (group feeding). Over the 174-day period, the steers fed the wheat-barley ration made gains of 2.07 pounds daily. This was not significantly different from the 2.19-pound gains made by the steers on the barley ration. Cost per hundred pounds of gain for the steers fed the wheat-barley ration was $19.65. Wheat was included in this ration at $67/ton. The average daily gain for steers on the high-wheat ration was slightly less than for steers on the barley ration but feed requirements per 100 pounds of gain compared favorably.

Table 1.--Percentage composition of all-concentrate rations fed[1]

Ingredients	Barley ration	Wheat ration	Barley-wheat ration
Barley, steam-rolled	63.5	--	32.5
Wheat, steam-rolled	--	63.5	31.0
Dried molasses beet pulp	30.0	30.0	30.0
Soybean oil meal	4.0	4.0	4.0
Bonemeal	1.5	1.5	1.5
Salt	1.0	1.0	1.0
Protein (percent)	12	12	12

[1] Each ration had 20,000 IU vitamin A per steer per day.

At the end of the 174-day feeding period, the steers were graded. One steer in the barley-fed or control group graded prime, 8 choice, and 1 good. In the group having nearly two-thirds of their concentrate made up of wheat, 7 steers made choice, 3 good. Where wheat replaced only one-half the barley in the concentrate ration, all 10 graded choice. Data are shown in Table 2.

Table 2.--Three groups of steers fed roughage plus 4 pounds of concentrate for 84 days and then given a 90-day all-concentrate finish

Ration	Initial weight	Slaughter weight	Average daily gain	Feed per 100 pounds gain	Cost per 100 pounds gain[1]
	Pounds	Pounds	Pounds	Pounds	Dollars
Barley	628	1003	2.16	1262	$17.90
Wheat	630	986	2.04	1268	19.87
Barley-wheat	624	984	2.07	1311	19.65

[1] Feed prices per ton: Alfalfa hay $24, corn silage $9, barley $50, wheat $67, soybean oil meal $111, salt $36, dried molasses beet pulp $37, bonemeal $100.

Results during final finishing period. Small amounts of hay and corn silage were fed during the first ten days of the final finishing period. This was made necessary in the switch-over from a high-roughage to an all-concentrate ration. For comparisons of barley and wheat rations in the final period see Table 3.

Table 3.--A 90-day comparison of 3 all-concentrate rations

Ration	Starting weight	Slaughter weight	Average daily gain	Concentrate per 100 pounds of gain	Cost per 100 pounds of gain
	Pounds	Pounds	Pounds	Pounds	Dollars
Barley	806	1003	2.19	889	$22.34
Wheat	815	986	1.90	861	26.22
Barley-wheat	796	984	2.08	885	24.52

Again, the barley-fed group of steers produced the most economical gain. However, the difference between the barley-fed and the barley-wheat-fed groups was not significant. The combination of 1/3 each of wheat, barley, and dried beet pulp compared very well with the high-barley ration. There was no problem in obtaining maximum consumption.

Since the cost of wheat is much lower than in 1963, a table has been prepared to show what beef gains made with wheat would cost as compared with barley. Assuming a $40/ton price for both grains, gains where wheat replaces half the barley in the ration would cost $19.38 as compared to $19.50 for the barley ration.

Table 4.--What gains would have cost over a 90-day feed period if wheat and barley each were available at $40 per ton

Ration	Total feed cost[1/] Concentrate	Total feed cost[1/] Hay and silage	Average daily gain	Concentrate per head per day	Cost per 100 pounds of gain
Barley	$376.59	$7.49	2.19	19.5	$19.50
Wheat	316.61	5.12	1.90	16.4	18.81
Barley-wheat	356.96	6.46	2.08	18.4	19.38

[1/] Includes cost of small amounts of hay and corn silage fed during the 10-day change-over period from high-roughage to all-concentrate rations.

At the request of the Idaho Cattle Feeders Association's Research Advisory Committee a second wheat feeding trial was conducted during 1964-65. Sixty heavy steer calves averaging 600 pounds were selected and allocated to lots of 10 each on the basis of grade and weight. These steers were started on a high-roughage growing ration made up of 6 parts corn silage (moisture basis) and 1 part chopped alfalfa hay with 4 pounds of a concentrate mixture. After 84 days they were switched to a non-roughage ration. In total, the steers were fed 174 days. For percentages of ingredients for each concentrate mixture see Table 5.

Table 5.--Concentrate mixtures and ingredients, parts per 100

Ingredients	Lot number 1	Lot number 2	Lot number 3	Lot number 4
Barley, steam rolled	63.5	--	31.7	23.5
Wheat, steam rolled	--	63.5	31.8	23.0
Dried molasses beet pulp	30.0	30.0	30.0	47.0
Cottonseed	4.0	4.0	4.0	4.0
Bonemeal	1.5	1.5	1.5	1.5
Salt	1.0	1.0	1.0	1.0
Diethylstibestrol, mg	50	50	50	50
Vitamin A concentrate, gm[1/]	5	5	5	5

[1/] Vitamin A concentrate has 20,000 IU per gram.

The experimental feeding began on November 10, 1964 and was completed May 3, 1965. The roughage was fed from November 10th to February 2nd. The non-roughage mixture was fed the last 90 days of the period. The purchase prices of feeds used in the experiment are shown in Table 6.

Table 6.--Purchase price of feeds used in the experiment

Feedstuff	Ton price	Feedstuff	Ton price
Barley	53.00	Alfalfa hay (chopped)	27.50
Wheat	53.00	Corn silage	9.00
Dried molasses beet pulp	40.00	Bonemeal	100.00
Soybean oil meal	112.00	Salt	33.20

Only four of the six lots of ten steers each will be considered in this presentation. The data presented in Tables 7, 8, and 9 show the initial and final weights, average daily gains, feed per 100 pounds gain, and cost per 100 pounds of gain for the first 84 days, the last 90 days and the entire 174 days.

Table 7.--Average initial and final weights, average daily gains, feed per 100 pounds gain, and cost per 100 pounds gain for the first 84 days' roughage feeding period

Lot no.	Rations	Weights Initial	Weights Final	Average daily gain	Feed per 100-lb gain	Cost per 100-lb gain
1	Barley, 30% DMBP	609	826	2.59	1373	$11.31
2	Wheat, 30% DMBP	604	799	2.32	1437	12.06
3	Barley, wheat, 30% DMBP	602	817	2.57	1311	10.94
4	Barley, wheat, 47% DMBP	605	811	2.45	1358	11.23

Table 8.--Average final weights, average daily gains and rations, feed per 100 pounds gain, and cost of 100 pounds gain for the last 90 days non-roughage feeding period

Lot no.	Rations	Final weight	Average daily Gain	Average daily Ration	Feed per 100-lb gain	Cost per 100-lb gain
		lb	lb	lb	lb	dollars
1	Barley, 30% DMBP	1044	2.42	21.9	902	$22.38
2	Wheat, 30% DMBP	993	2.16	17.6	818	20.18
3	Barley, wheat, 30% LMBP	1020	2.26	20.2	895	22.13
4	Barley, wheat, 47% DMBP	1024	2.37	20.0	844	20.06

Table 9.--Average initial and final weights, average daily gains, feed per 100 pounds gain, cost of 100 pounds gain of each lot for the entire period of 174 days

Lot no.	Rations	Weights Initial	Weights Final	Average daily gain	Feed per 100-lb gain	Cost per 100-lb gain
		lb	lb	lb	lb	dollars
1	Barley, 30% DMBP	609	1044	2.50	1137	$16.86
2	Wheat, 30% DMBP	604	993	2.24	1128	16.11
3	Barley, wheat, 30% DMBP	602	1020	2.40	1111	16.38
4	Barley, wheat, 47% DMBP	605	1024	2.41	1097	15.72

As shown in Table 7 the average daily gains and costs per 100-pound gain were not greatly different. In the final 90-day all-concentrate finishing period (Table 8) wheat compared very favorably in cost per 100 pounds of gain. The cheapest gains were made by the steers in the lot fed 47 percent DMBP with 24 percent barley and 23 percent wheat. The most rapid gains were made by the steers in the lot fed 64 percent barley and 30 percent DMBP. However the overall performance of the 4 lots of steers did not differ greatly. As shown in Table 9 the steers fed 47 percent DMBP with barley and wheat made the cheapest gains. The data representing gains, feed intakes, and costs of gains are similar for all lots. The comparative USDA carcass grades of steers of each lot are shown in Table 10. The monetary returns per steer as calculated from initial cost and total feed cost are shown in Table 11. The greatest net returns were made in Lot 4, fed 47 percent DMBP. Lot 1, fed barley with 30 percent DMBP, had the highest average total feed costs.

Table 10.--Comparative USDA carcass grades of steers of each lot

Lot no.	Prime	Low prime	Choice	Low choice	High good	Good	Low good	Average[1/]
1	1		2	4	1	1	1	10.0
2			3	3	1	2	1	9.5
3		1	3	3	2		1	10.1
4	3		2	3	2			11.2

[1/] Based on numerical scores: 15 = high prime; 12 = high choice; 9 = high good.

Table 11.--Monetary returns per steer calculated from initial cost and total feed costs

Lot no.	Rations	Average initial cost	Average feed cost	Total cost	Gross[1/] returns	Net returns
1	Barley, 30% DMBP	$131.85	$73.34	$205.19	$238.63	$33.44
2	Wheat, 30% DMBP	130.77	62.66	193.43	226.29	32.86
3	Barley, wheat, 30% DMBP	130.33	68.46	198.79	233.98	35.19
4	Barley, wheat, 47% DMBP	130.98	65.86	196.84	237.18	40.34

[1/] Based on carcass grades: choice under 700 lb - $40.00; choice 700 up - $39.50; good under 700 lb - $37.50; good 700 up - $37.00.

Notes and observations. There were no cases of bloat. In Lot 2 (wheat with 30 percent pulp) two steers showed signs of founder. Six steers had abscessed livers in Lot 2. There were no abscessed livers in Lot 1 and one abscessed liver each in Lots 3 and 4.

Summary and conclusions. Maximum consumption of an all-concentrate ration can be obtained when the ration is approximately one-third wheat, if barley and beet pulp are included. Even higher levels of wheat can be fed in all-concentrate rations with good results when wheat is competitively priced with other grains. Where wheat is competitively priced it should be considered for use in feedlot rations. Work at the Caldwell Branch Station shows conclusively that wheat can make up to 1/3 of typical Idaho nonroughage beef-finishing rations without depressing feed consumption or rate of gain. Excellent gains and feed efficiency will be realized with wheat substituted for half the barley in Idaho all-concentrate rations. Good success can be expected where wheat replaces barley entirely, if beet pulp is included in the ration.

MALTING TO IMPROVE THE FOOD AND FEED VALUE OF WHEAT

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Although the belief that moistening grain and/or germinating it prior to its use as feed increases its feed value appears to be widespread, there is little documentary evidence either in support or disproval. The expense involved in malting cereal grains would require that a very marked improvement result in order to make the procedure at all feasible. A series of experiments were begun to test the effect of germination on the protein efficiency ratio (PER) of wheat fed to weanling rats. Rations were prepared having the following composition:

Ingredient	Percent	Ingredient	Percent
Protein (Nx6.25)	10.0	Ash	4.5
Oil	4.2	Moisture	9.5
Fiber	3.0		

The rations were supplemented with a vitamin mix and made to 100 percent with sucrose.

The results obtained thus far have given indications of an increased PER brought about by the germination (at 38 percent moisture and 12°C.), for 2 and 4 days, of Minter wheat. Thus in one series of experiments the PER was 0.96 for ungerminated wheat, 1.17 for 2-day germinated wheat, and 1.32 for 4-day germinated wheat. Replacement of 0.5 percent of the wheat protein with an equivalent amount of casein brought about an increase in PER of all samples. Surprisingly the germination of barley for 2 days caused no change in PER although marked increases in weight gained and food consumed accrued. The greatly increased rate of food consumption seen in the germinated barley rations (22 percent) was not observed in the germinated wheat rations where food consumption remained about the same but growth performance in the germinated rations was improved.

WHEAT IN ANIMAL AND HUMAN NUTRITION, CHALLENGES TO RESEARCH

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In the 1920's dog biscuit in several forms was the major source of commercial dog food. Spratts Ltd. had a substantial volume of the market at that time. The biscuit was mixed with cooked meat, broth, and vegetables to prepare what was believed to be a balanced diet for dogs. It was basically No. 2 white flour, baked at high temperatures to convert the raw starch to a digestible form. At that time a bleaching agent, Agene, was widely used in the flour industry to produce a clear white flour.

Cooperative studies in our laboratories, located at that time in Edison, N.J., with Wallace and Tiernan, owners of the Agene patents, confirmed that Agene was directly responsible for a nervous disease of dogs known as "frights disease" or "running fits". These studies resulted in the adoption of other methods for the bleaching of flour since the Government health agencies believed that the toxicity of Agene might affect man.

In an effort to nourish dogs with products containing ingredients other than broken biscuit, cereal by-products from the breakfast food industry such as corn flakes, wheat flakes, rice, etc., were blended and mixed with dehydrated meat scraps, bone meal, and vitamin mixtures to produce a product marketed as "a complete dog food" in meal form. The rights to this meal business became the property of General Foods Corporation.

The canning industry, utilizing horsemeat, horsemeat by-products, beef, and beef by-products, blended certain amounts of cereal grains, primarily pearl barley, which laid the groundwork for what is today the canned pet food industry.

Data provided by A. C. Nielsen Research indicates that canned moist dog foods command the number one position. In 1962 the American public purchased 1.46 billion pounds of canned dog food and an estimated 1.62 billion pounds in 1965. This represents a 10 percent increase in total sales of canned dog foods from 1963 through 1965. In the same period, the dry food industry, which includes all forms (biscuits and meals), increased from over 1.1 to in excess of 1.2 billion pounds. It will be noted that sales in the dry food industry have leveled off since 1964. Why?

In 1963, so-called soft, moist dog food, packaged in several ways, entered the market and was, and still is, widely promoted. In 1963, sales of this type of food were less than 100 million pounds but in 1965 sales are approaching 200 million pounds; thus, research in food technology, packaging and marketing has introduced a product which apparently has the potential of influencing the volume of both canned and dry foods.

With our rapid urbanization, the cat is becoming a more popular companion, readily adaptable to apartment and urban housing. Cat food today is marketed in canned, soft, moist, and dry forms. In 1962 sales amounted to approximately 4.5 million pounds but in 1965 sales are pegged in excess of 600 million pounds; thus, this is a rapidly growing industry.

Information based on Nielsen figures gives some idea of the pet food dollar volume. In 1958 it was a $350 million business. In 1965 it should be a $540 million business. At present rates of increase, Nielsen estimates in 1968 that the dog and cat food business should amount to $700 million.

Another animal now classified as a companion and frequently overlooked is the horse. Our horse population is growing, not declining, because of wide interest for recreational purposes. The horse population today may well exceed 6 million (double the figure of 6 years ago) and compares to a maximum figure of 23 to 25 million when the horse was at its peak. A mature horse in a dry lot, consuming only pelleted feed, eats about 10 pounds a day. Potential pellet consumption, if one-fourth of the horse population were fed this way, would be 5 billion pounds a year.

At present, whole wheat is considered unsuitable for feeding horses. However, based on experience at our laboratories in feeding a purified diet, it is estimated that it may be possible to employ up to 30 percent wheat in a ration for horses. Before this can be done, further research is needed to define the proper ingredient balance.

In addition to the commercial dog, cat, and horse feed industries, there is also a dietary animal food business which I started in 1948. These products are marketed through professional channels or on prescriptions from veterinarians. There are now several companies marketing dietary animal foods and this total business, estimated at 30 to 40 million pounds a year, continues to grow steadily, providing a growing potential for the utilization of wheat as one of the ingredients. The amounts of wheat used in dog and cat foods is unknown; however, the departments of nutrition and food technology at our laboratories believe that 5 percent of wheat or wheat products are, or could be, employed in the manufacture of foods for dogs and cats--a possible potential of 180 million pounds of wheat a year.

In the utilization of wheat in dietary foods for the dog and cat it has been found that this grain has certain assets as listed below:

WHEAT AS A NUTRIENT

Assets

1. Good source of energy.
2. Can be supplemented to make a palatable diet.
3. Wheat germ is a good source of vitamin E and other nutrients.
4. Bran is a good source of trace nutrients and for bulk.

Liabilities

1. Geared more for human food, thus increasing price.
2. Protein has amino acid imbalance.
3. Nitrogen balance index is low for dog, cat, and man.
4. Contains allergy-inducing proteins.
5. May cause enteritis or diarrhea.

PROCESSING OF WHEAT

Assets

1. Dry, dense product lends to bulk storage and automated handling.
2. Preserves well--quality control easy.
3. Starch and gluten plus water give formed product.
4. Viscosity increase comes after product is in package.
5. Particle size flexibility.
6. Supply available in many areas.

Liabilities

1. Must be cracked or ground.
2. Abrasive on pumps and pipes.
3. Lodges under check valves.
4. Stickiness from gluten.
5. Gluten limits mixing time.
6. Supply of hard, good-quality grain limited.
7. Increases ingredient costs.

Experience over years through research with the dog and the cat in the development of foods to assist in the management of certain diseases, has we believe established a basis from which research in the future in comparative nutrition as applied to man might well be instituted. An examination of the brochure titled, "Program of Proposed Research, Wheat Foods in Human Nutrition," sets forth recommended areas for future research. I have selected a few in which research with the dog and cat have made and can continue to make a valuable contribution.

Evaluation of protein. The dog is valuable for use in the evaluation of the biological value of protein. Many of these values can be employed in determining the value of a protein to be consumed by man.

Evaluation of lipids. At our Topeka Laboratory we have beagle dogs which, for certain reasons, have excessively high serum cholesterol levels. Although lipid metabolism in the dog and man is different, studies with such animals might well contribute to our knowledge of cholesterol metabolism in man.

Malnutrition. This is a broad term; however, it is possible to produce well defined and highly specific states of malnutrition in the dog and compare the symptoms and pathological findings with those recorded for man.

Atherosclerosis. Reports from thousands of necropsies on dogs and cats reveal that these animals rarely develop this disease. Why? Studies on dogs might well contribute toward a break-though in this important field. Necropsy studies on aged male swine, however, indicate that this animal, under certain conditions, does develop atherosclerosis. Thus, a comparative study of the nutrition of the dog and the pig could be most valuable.

Obesity. In conducting research on dietary foods for dogs, one of the first developed and marketed in 1948 was a reducing diet for the obese dog. There are instances where ill effects of obesity in the dog are comparable to those reported in man. Pancreatic disease, diabetes, and fatty diseases of the liver are illustrations.

Anemias. These are common in both the dog and cat. A certain form of anemia which develops in the suckling pup during the first three weeks of life can easily be traced to malnutrition of the mother during gestation and lactation. The death rate among such animals is high and once developed, it is difficult to reverse. Both dogs and cats can make valuable contributions in studies involving anemias.

It is obvious that a well organized, efficiently executed research program is essential to point up the role of wheat in the nutrition of man and animals. Procedures are needed to determine how wheat can be incorporated into the dietary regimens of both man and animals in many foreign populations. The exporting of raw wheat will in itself prove insufficient to accomplish the total objectives. The report of the committee which formulated the "Program of Proposed Research, Wheat Foods in Human Nutrition," is certainly sound. Available data are largely based on studies conducted in past years and may or may not be entirely correct. Methods for evaluating the nutritive value of foods have been upgraded substantially in the last 10 years. There is a great need for application of such techniques to this problem. Such methods must be employed if we are to accurately appraise the nutritional status of world populations and then determine the most effective techniques of correcting malnutrition and controlling associated diseases. It is essential that more capable people be trained in the nutritional sciences so that an appraisal can be made of how wheat or wheat products can be employed in human and animal diets throughout the world. It would appear that we are facing a problem of blending and processing foodstuffs which can become a part of the diet of people accustomed to maintaining themselves on native foodstuffs. A classic example is research and development by Nevin Scrimshaw, M.D., in Guatemala which resulted in the development of Incaparina--a protein supplement for native food consumed in Central America.

But caring for the nutritional requirements of the people of the world today is not enough. Dr. Ernest L. Stebbins, Dean of the Johns Hopkins University School of Public Health, recently told a Senate Government Operations Subcommittee: "At the rate of growth of the population, it will be necessary in the next 40 or 50 years to double the provisions for housing, education, food production, and all elements of our standard of living, if we are to maintain just the present level." Frank Carey, Associated Press Science writer, reports that a blue-ribbon committee of the National Academy of Science predicts a population of 3 billion for the United States in a century and a half if present fertility trends and low mortality rates persist. Entirely new concepts in agriculture and in food processes and nutrition must be developed to care for the exploding populations--in our own country and throughout the world. Federal and private population experts are predicting wide-scale famine in parts of the world by the early 1970's. Already India is having severe food problems. International and national leaders are urging attention to the great and increasing problem of proper food for the increasing masses of people.

Where do we start? It seems that one effort should be to upgrade the quality of wheat grown in the United States. Progress is being made in this effort but it will require continuing research of substantial magnitude. The grower must be shown how to produce not only quantity but quality. In our dietary animal food business in Topeka, Kansas, the type of wheat available in our area is unsatisfactory; thus we ship in northern hard wheats to avoid excessive stickiness in products manufactured. We must therefore not only change the chemical composition of the wheat grown but its biological value as well--a substantial, time-consuming project. This requires the projection of a philosophy that has not pervaded the industry in the past. Large quantities of chemical fertilizers are employed. These could well influence the biological value of the grain. Chemical methods in themselves may be totally inadequate to define these values; thus, comparative biological studies will be mandatory if the work is to move forward expeditiously.

Such a realistic research effort is not one for the agricultural specialists alone, or the food processors, or the milling experts, or the nutritionists. The effort must be a well-designed, multidisciplined, multiorganizational attack on the total problem of wheat foods in human nutrition. Specialists in many areas of human endeavor, including finance, politics, international relations, psychology and psychiatry must pool their efforts.

But we know so very little about multidiscipline, multiorganizational interactions. Only now is the Federal Government doing something about processing the results of research and development generated by the vast research and development effort of this Nation--through the NASA Technology Utilization Program and the new State Technical Services Act of 1965. A few states are taking unique steps to mobilize their research resources, public and private, for the benfit of their people. The Georgia Science and Technology Commission and the Connecticut Research Commission are notable examples.

A growing number of people in Kansas are concerned about the future food and nutrition requirements of mankind--and the possible use of wheat for meeting the requirements. A program in cereal foods and nutrition is emerging as one of the priority programs of research for the State. The program has as its objective the pooling of the resources of the State, public and private, in a coordinated comprehensive study of wheat and wheat foods and their potential in animal and human nutrition. In Kansas, such a program transcends the splendid accomplishments in agriculture and milling of Kansas State University and the fine contributions of the University of Kansas Medical Center in medicine and human nutrition. The program would coordinate these contributions and those of other specializations, including the food processing industry of the State, in a long-term research effort.

Senator Frank Carlson of Kansas, in an Associated Press report of October 21, announced that the Senate had added a $225,000 appropriation to start plans for a national grain marketing research laboratory to be constructed at Kansas State University in Manhattan. "The current research program is progressing too slowly and is limited in scope. Large stocks of grain have accumulated on which the Government pays storage. The quality of U.S. grain delivered to foreign markets has been criticized. Practical solutions to these problems are of vital importance to the grain producers, to the grain industry and to the consumers of all grain products," the Senator said.

The Research Foundation of Kansas, whose Executive Director was a member of the Pro Tem Committee which prepared the report on "Program of Proposed Research, Wheat Foods in Human Nutrition," is attempting to pull this program together in Kansas. The Research Foundation was created by the 1963 Kansas Legislature to: (1) Overview, coordinate, and stimulate research in the state, public and private, in all areas of intellectual endeavor, (2) overview, coordinate, and stimulate the use of the results of research and development for the benefit of the State.

The Research Foundation has been accumulating information on wheat foods and nutrition from numerous sources and is attempting to develop the comprehensive plan for the program. The problems being faced and yet to be faced are gigantic in nature and proportion. They include the development of a systems approach for a tremendously complex area of human endeavor and the encouragement of greater university participation in directed research at the same time that the student population is growing rapidly. In addition, the creation of new concepts of communication and coordination between the public and private sectors of our society is needed to provide the accumulation of adequate resources, human and financial, for the job. But the job needs doing and the State of Kansas is not afraid to tackle it.

Those of us working with wheat are privileged people. We are working with a unique source of energy and nutrition. We may well be working with a resource that will help to supply the answer to tomorrow's food and nutrition requirements. But we have work to do. Are we capable of doing the job? I am sure that we are--if we team up for an effort in our fields such as has been coordinated so successfully in the physical sciences and technology, i.e., in the development of radar, the atomic bomb, space technology, the advanced computer systems.

Sources of Federal Funds for the Performance of Extramural Research and Development in Fiscal Year 1963

(Figures extracted from: Subcommittee on Sciences, Research and Development of the Committee on Science and Astronautics, U.S. House of Representatives Report No. 4 on "Government and Science" transmitted on October 23, 1964, page 4. U. S. Government Printing Office, 1964).

Agency	Percent
Department of Defense	57.0
NASA	24.5
Atomic Energy Commission	10.6
Department of Health, Education and Welfare	5.1
National Science Foundation	1.3
Department of Agriculture	0.4
Department of the Interior	0.2
Department of Commerce	0.1
Other agencies	0.8

Are human food and nutrition problems any less important than these scientific and technological problems? Heavens, no! There are many who are beginning to say that peace will be won in this world, not through munitions and weapons of war, but by food for the hungry mouths of tomorrow. Wheat is very likely an answer.

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